ENVIRONMENTAL EXPLORATIONS PROGRAM

LEARNING THE ENVIRONMENTAL WAY

Environment
Ontario

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INTRODUCTION

For several years, Environment Ontario has offered a unique educational program throughout the province.
Called **Environmental Explorations**, this program consists of studies for school children from Grades 1 to 8. The studies, which are conducted by Ministry-trained university or college summer students, are offered in the later part of the school year and during the summer in parks and camps around the province.

The **Environmental Explorations** program is designed to foster a clear awareness and concern for the environment and to encourage appreciation of the out-of-doors. It aims to motivate people of all ages to take an active part in environmental improvement and protection.

Learning the Environmental Way provides environmental activities and games that leaders can use to design and deliver their own environmental explorations program during the regular school year and at other times.

The book is divided into three main parts. **Part One** has seven study units. Each unit focuses on one aspect of the environment and includes objectives, concepts, background information and a wide variety of activities and experiments for hands-on discovery and learning.

Part Two has over 57 environmental awareness games divided into five categories. Each category focuses on one environmental theme. The games may be played as described or adapted to suit the needs and interests of participants. Leaders are encouraged to exercise their creativity by both using the games in different ways and by using them with different age groups, from children to adults.

Part Three has some reference and resource materials which you may find useful. The games, activities and information in this book may be reproduced for non-profit, educational purposes without further permission from Environment Ontario as long as the source is acknowledged. Please note,however, that this permission does not apply to games drawn from other sources. In those instances, the permission of the copyright holder is required.

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PART ONE:

ENVIRONMENTAL STUDIES

ACID RAIN

Activity 13: Volcanoes

Conduct research on volcanoes as a natural source of sulphur dioxide. Major volcanoes are Mt. Etna (Sicily), Mt. St. Helens (U.S.A.) and Mt. Vesuvius (Italy).

Activity 14: Emissions Debate

Have a class debate between representatives of an industry which produces acid rain and representatives of a citizens' group which wants the industry to reduce its emissions. Conduct research on what is being done in that industry at present, what other techniques are being developed, the advantages and disadvantages of the various methods and the costs involved.

Activity 15: Local Focus

Select businesses and industries which are important to your area and which may be affected by acid rain. (Examples are fishing, forestry, agriculture and tourism.)

Contact local representatives of each. Do they think acid rain poses problems for business and industry? If so, in what ways? What do they think are the solutions?

Activity 16: Real World Solutions

Collect news clippings on acid rain. What are the main barriers to reducing acid rain levels? Are they mainly political? Technical? Economic?

Activity 17: Community Survey

Conduct a survey in your community on awareness about acid rain. Are residents of your area generally aware of the issue? Should they be more aware? How could this be achieved?

Activity 7: Filtering Time

Prepare 400 mL of pH 2.0 or 3.0 solution. Put 200 mL each in clean glass containers.

Add 200 g crushed granite to one container and 200 g limestone to the other.

Measure and record the pH level of the solutions immediately. After 10 min, measure and record the pH levels again. Also, record your observations.

Drain the solutions into separate collection beakers. Measure and record the pH levels again.

Discuss the results.

Activity 8: Soil

Repeat **Activity 7** using a variety of non-organic soil types common to your area. Use rainwater rather than a prepared acid solution.

Another variation is to take two soil samples and add agricultural lime to one but not the other. Repeat the experiment and compare the pH levels of the drained liquids. Does lime neutralize acid rain?

Activity 9: Chalk

Prepare several acid solutions with different pH levels. Add a spoonful of ground chalk to each, shake the container and test the pH again. Discuss the results. Why is lime sometimes added to lakes to raise the pH?

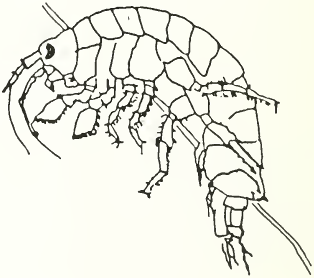
Activity 10: Effects on Amphipods

Prepare 100 mL each of solutions with a pH of 6.0, 5.0, 4.0 and 3.0. Put each in a clean glass jar, and label.

Place two amphipods into each container. (These scuds or sideswimmers can be found in ponds and streams among decaying vegetation and under stones or rocks. They are usually from 5 mm to 15 mm long. A butterfly net will be helpful for catching the supply you need.)

Observe the behavior of the amphipods for 10 min to 15 min and record your observations.

Discuss these questions:



1. What might occur to amphipods in a stream if an early spring thaw produced water with a pH of 5.0?
2. What might occur to amphipods in a lake fed by this stream?
3. What behaviors indicated that the amphipods were in trouble?
4. Do you think that amphipods might be useful as indicators of the relative health of an aquatic ecosystem? Why?

Activity 11: Effects of Factories and Power Plants

Mark locations of factories and power plants on a map of your area. Choose several locations where rainwater collection jars may be placed. (Some should be near factories and other in residential areas.) Set out short, wide-mouthed jars in the selected locations just before it rains.

Collect and test the pH levels of the rainwater samples.

Activity 12: Life Collage

Draw or collect pictures of the effects of acid rain on fish, wildlife, plants and people. Make a class bulletin board display.

ACID RAIN

Activity 1: Rainwater Samples

Measure the pH of a variety of rainwater samples and then answer these questions.

1. Does it make a difference if the rain is collected at the beginning or end of a storm?
2. Does it make a difference if the rain is collected during a violent (thunder)storm or during a gentle rain?
3. Does it make a difference if the rain is collected directly (in the open using a rain gauge) or indirectly (such as a can below the eaves or through a downspout)?
4. Does the direction of the storm make a difference? (Hint: Use newspaper weather maps or television weather news to trace the path of the storm. Did it pass over any large cities or expanses of farmland?)
5. Does it make a difference if the rain is collected at night or during the day? During the week or the week-end?
6. Do you think it would make a difference if the water came from snow rather than rain?

Activity 2: Other Samples

Measure the pH of a variety of common and safe solutions. Examples are shampoo, fruit juice, baking soda, vinegar, tap water, ammonia, spring, pond, or swamp water, distilled water, antiseptics and household bleach. Disguise them by using food colorings and putting the samples in jars identified only by number.

Use the master identification list to record the pH readings obtained. If you wish, have students try to identify the solutions as well as take readings.

Discuss the results.

Activity 3: Roots

Plant cut ends of coleus, begonia or African violet leaves in vermiculite, perlite or soil. Water some with rainwater, some with tap water and some with water of five different pH levels (such as 2.0, 4.0, 6.0, 8.0 and 10). Note how long it takes for the roots to develop in each case.

Discuss the results. Which plants grow fastest and why?

Activity 4: Seeds

Repeat **Activity 3** using seeds instead of plant ends.

Activity 5: Fabric Filters

Cut pieces of fabric (such as cotton, wool and a variety of synthetics) into pieces a little larger than a 135 mm slide mount opening. Stretch each cloth sample over a slide opening and tape on to the side tightly (so that there are no wrinkles).

Label each slide mount with the pH value of the stock solution that will be used to test it.

Set each slide on top of a microscope slide, label side up. The microscope slide will catch any acid that might drop through.

Place one drop of the appropriate acid solution on each fabric filter. Observe the mounts for a few days and record your observations. If a drop dries up or disappears, place another one in the same location.

Activity 6: Aggregate Filters

Prepare 900 mL of pH 4.0 acid solution. Put 300 mL each in clean glass containers.

Add crushed granite to one container and marble or limestone another. Do not add anything to the third.

Measure and record the pH level of the solution in each container immediately. Also, record your prediction on what the pH level will be one week from now.

Measure and record the pH level of the solution in each container every day for a week.

Discuss the results.

reduction. The capital costs could be as high as $450 million for the mining industry alone. The estimate for Ontario Hydro is $1.6 billion (in 1985 dollars).

These initiative are supported by the public as a whole. One survey of Ontario residents indicated that 97% had heard of acid rain and 73% agreed with the following statements:

- No requirement or standard is too high when it comes to protecting the environment.
- The Government of Ontario is "too soft" on companies which pollute the environment.
- Protecting the environment is so important that continuing improvements must be made, regardless of cost.

In addition, 83% disagreed with the statement that we must relax environmental standards in order to achieve economic growth, and 75% said that they would be willing to pay higher taxes and consumer prices to prevent further deterioration of the environment.

At the same time, many people are concerned about the economic effects of spending millions of dollars on such programs as sulphur dioxide emission reductions. As a rule, however, abatement spending represents a re-directing of resources rather than a loss. For example, funds are paid to companies which hire people to do the abatement work, buy parts from suppliers, pay taxes and generally contribute to the economic activity of the region. As well, everyone benefits from a cleaner environment.

Nevertheless, a major abatement program will require economic sacrifices for some time to come. The reward will be preserving and enhancing our environmental heritage for ourselves and coming generations.

ACID RAIN ACTIVITIES

Before You Start

1. Collect rainwater in your area. Place a clean glass container in the open where it can catch rain falling freely from the sky.
2. Have a supply of sulphuric acid and distilled water available. (Many of the activities require them.) You may obtain sulphuric acid from a high school science department and distilled water from a drug store.
3. Practice preparing acidic precipitation below 7.0 pH level. Note that the process will generate a great deal of heat. Protect yourself and others by taking these safety precautions:
   - Wear gloves, safety glasses and a protective apron.
   - Work near a sink so that spills can be wiped up easily.
   - Use tongs to handle the mixing container.
   - Do not allow acidic solutions to come in contact with skin or clothing.
   - Do not attempt to lower the pH level below 2.0.
4. To make acidic precipitation, follow these steps in this order. Otherwise, there could be a serious accident due to the amount of heat generated.
   - Add sulphuric acid, drop by drop, to distilled water.
   - As you add the drops, stir the solution constantly and thoroughly.
   - Measure the pH level frequently. Use pH paper or a pH meter.
   - When you reach the desired level, wait one minute and then measure again to confirm. Never try for a pH level below 2.0.
5. Review the activities. Select those you think would be most useful, and plan for students to do as much of the preparation, set-up, research and follow-up as possible. For example, students could (under your direction) collect and label samples, arrange for interviews with local experts, prepare survey questions, conduct newspaper and library research, set up debating teams, lead discussions of experimental results, etc.

ACID RAIN

The Air Pollution Index

An Air Pollution Index has been established in several cities in Ontario. It measures sulphur dioxide and particulates. If the index reaches an alert level, the Government has the power to order temporary cutbacks in emissions (through reduced operations). This power, under the Environmental Protection Act, is rarely needed now because local sulphur dioxide and particulate levels have been reduced significantly over the past 15 a (years).

Other Air Pollutant Damage

Damage to forests is usually in the form of thinning of the canopy, decreased growth and increased tree deaths. Several species of trees (such as sugar maple, red spruce, beech, pine and ash) of all ages have been affected in both North America and Europe.

Although the evidence is not yet conclusive, forest damage of this type is not in areas which do not receive higher acid depositions. Examples are northern Sweden, Norway and northwestern Ontario. However, Sweden has reported recently that damage to its forests corresponds to areas of surface water acidification.

In the Republic of Germany, the scientific consensus is that air pollution does cause forest damage. Thus, the Government is moving to control sulphur dioxide and nitrous oxide emissions, even though the exact cause and effect relationship is not yet known. The onus of proof is now on the shoulders of the alleged polluters, who must demonstrate that their particular pollutants are not causing forest dieback.

Several theories may explain how air pollution is causing damage. One, the **shoots** theory, holds that leaves are first damaged by ozone, which increases the rate of nutrient leaching. This is aggravated by the acidity of rain. Nitrogen oxides are implicated because of their role in contributing to ozone formation and to the low pH of rain. Sulphate is also implicated in the low pH of rain.

The **roots** theory holds that fine roots are damaged by low pH in soil water and so are unable to gather sufficient nutrients. Sulphate is a major cause of acidification of soil water, but nitrate plays a role as well.

Nitrous oxides are created by chemical reactions during high-temperature combustion and by burning nitrogen compounds contained in coal and other fuels. These oxides contribute to the creation of ozone, which is known to harm human and plant life.

Economic Impacts

Environment Ontario has conducted a number of economic impact studies since 1982. These studies have attempted to assess the economic impact of acid rain on tourism, agriculture, forestry and commercial fishing, trapping and hunting and the value of damages to buildings and other structures. Although not conclusive, these studies indicate major consequences if acid deposition continues.

One example is sport fishing. At present, some $265 million is spent in Ontario each year by people involved in sport fishing. This is about 29% of the $917 million (in 1980 dollars) Ontario earns each year from the promotion of its lakes and rivers. Fish populations are especially vulnerable to lower pH levels. If fish species are killed off, the economic benefits of recreational fishing could also be threatened.

Another example is the cost of repair or replacement of buildings and other structures which are damaged by acid rain.

One estimate is that between 1980 and 1990 the extra costs and reduced revenues will add up to some $400 million.

There are also social costs. Environmental damage which affects tourism and logging industries in turn affects the individuals who depend on those industries to earn a living. Finding satisfying alternatives for those individuals and their families is an enormous task.

The Cost of Abatement

On March 6, 1984, Canada's federal and provincial Ministers of the Environment agreed to reduce annual emissions in Canada to 2.3 million tonnes by 1994 (this is 50% of the 1980 base level). For Ontario, this means a sizable example, originate in the Ohio Valley of the United States.

During transportation, the sulphur dioxide and nitrogen oxides combine with water vapor and are converted into sulphuric acid and nitric acid.

Deposition

Wet deposition refers to acidic deposits by rain, snow, hail and sleet.

Dry deposition refers to acidic deposits of fly ash, sulphates and nitrate particles and of gases such as sulphur dioxide and nitric oxide. The dry particles and gases are converted into acids when they come into contact with water after they are deposited on surfaces or absorbed into them.

Sulphur Dioxide Damage

Effects on Aquatic Life

The main cause of rising acid levels in central Ontario's lakes is the acid deposits from emissions of sulphur dioxide from such sources as coal-burning plants and vehicle exhausts. In the large areas, which include the Precambrian Shield, the quartzite (or granite-based) geology and thin soil are unable to neutralize the acid. Melting snow and heavy rains result in short-term acidification episodes and contribute to the gradual decrease in the lakes' pH levels.

A survey of 6,063 Ontario lakes found that 4% (243) are acidified, 15% (909) are extremely sensitive to acid rain and 38% (2304) are moderately sensitive. It is, therefore, likely that thousands of lakes are experiencing biological damage.

Aquatic life is affected mainly by the combined toxic effects of acid and aluminum leached from the rocks and soil by the increased acid flow.

Changes or decreases in phytoplankton, zooplankton, fish and frog species are related to the disappearance of wildlife that feed on aquatic life.

Some or all species of fish disappear. Types of filamentous algae have been associated with lower pH levels. They tend to form large, unpleasant masses in shoreline areas of lakes, making them less attractive for recreational uses. Foul-smelling algae associated with sulphur compound deposits also contribute to the problem.

Studies have determined that some sensitive aquatic systems can handle deposits of 20 kg of wet sulphate per hectare per year (18 lb. per acre). This loading target is the basis for current sulphur dioxide emission reduction programs. At present, however, this target is exceeded in all of central and southern Ontario.

Studies of lakes in the Sudbury area proved that acidification can be reversed by reducing sulphate deposits. Ontario's new control program is, therefore, fully expected to have beneficial results. However, if comparable emission controls are not undertaken in the U.S.A., Ontario's lakes and streams will continue to suffer from sulphate emissions.

Effects on Plant Life

Dramatic forest die-backs and reduced tree growth have been documented in parts of Europe and North America. Just what role sulphur dioxide plays is not yet known. It is thought, however, that foliage and root damage may be linked to sulphur dioxide emissions, acid deposits, concentration of metals in the soil and leaching of nutrients from the soil. If this is the case, Ontario's sulphur dioxide program, which protects surface waters, will also provide some protection to Ontario's forests, especially when combined with actions to control nitrous oxide.

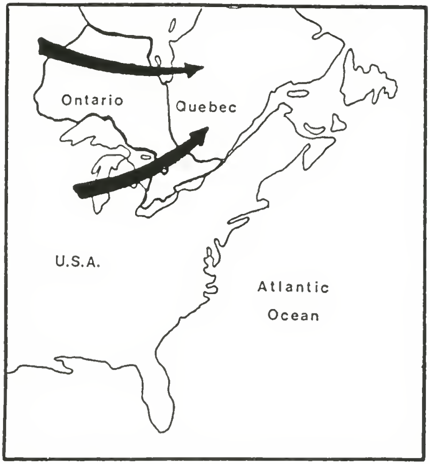
Effects on Human Life

Sulphur dioxide, sulphates and nitrate, combined with particulates and ozone, are known to cause human respiratory health problems, especially in children, the elderly and individuals with chronic lung and heart ailments.

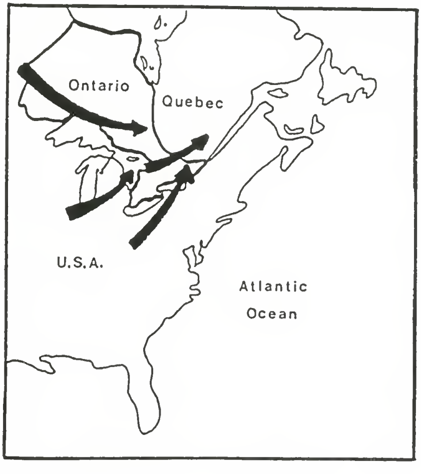
As well, pollution from sulphur dioxide and its oxidation products contributes to the rapid weathering of building materials, statues and rock paintings. Architectural design may be modified and different building materials used at considerable cost, but the long-term effectiveness of such measures have yet to be proved.

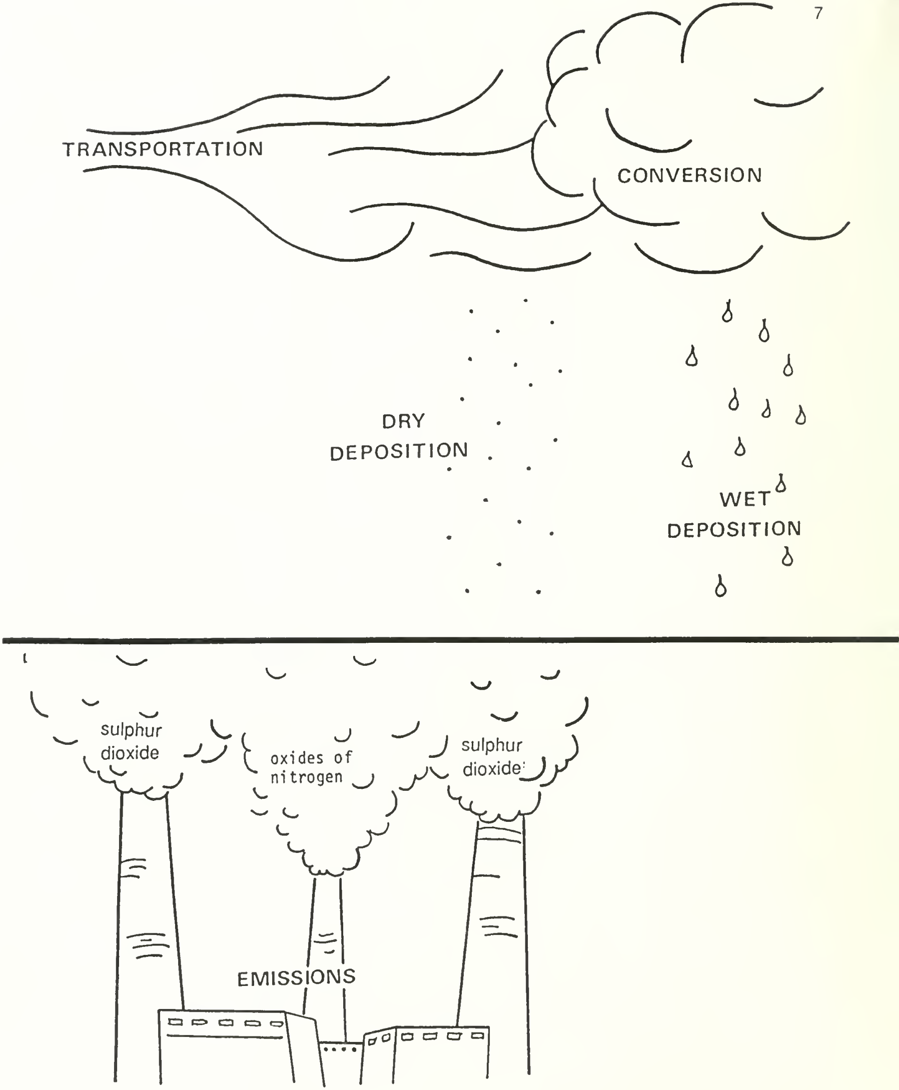
IMPORTANT STORM TRAJECTORIES OVER ONTARIO

SUMMER

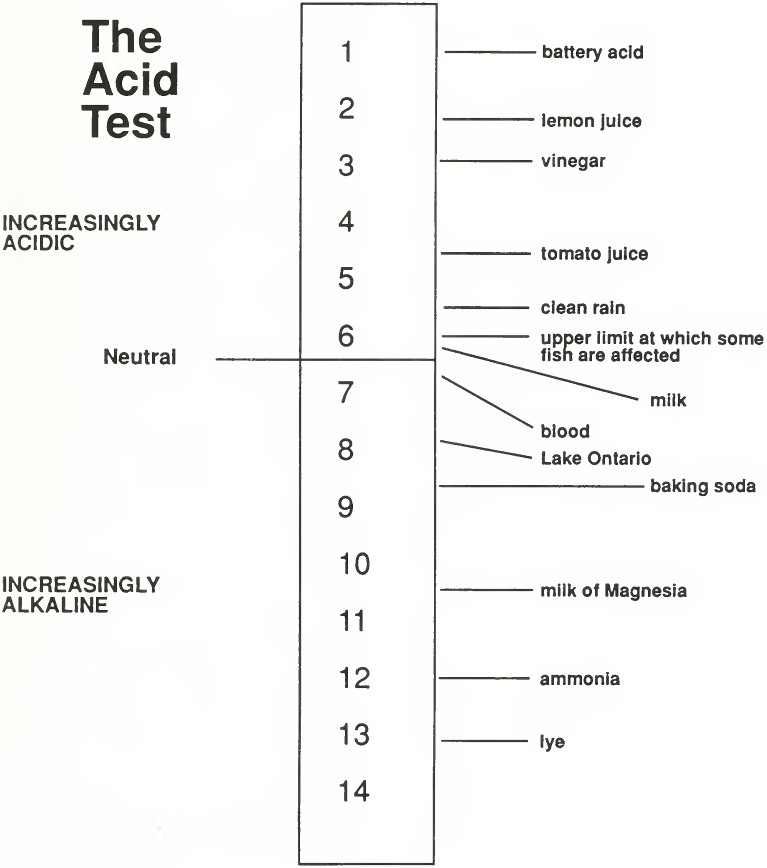


WINTER




TRANSPORTATION
CONVERSION
DRY DEPOSITION
WET DEPOSITION
sulphur dioxide
oxides of nitrogen
sulphur dioxide
EMISSIONS

The Acid Test



ACID RAIN

Acid rain is one of the greatest environmental threats facing Ontario and many other parts of the world today.

OBJECTIVES

1. To develop an understanding of the concepts and implications of acid precipitation.
2. To foster concern about the long-term effects of acid precipitation.

CONCEPTS

1. The pH scale measures the level of acidity of a solution. The scale uses gradations from 0 to 14.
2. **Acids** are substances with a pH of less than 7.0. **Alkalines** are substances with a pH of more than 7.0.
3. Acidic precipitation is defined as a deposit with a pH of less than 5.6.
4. Acidic precipitation forms as a result of chemical reactions between sulphur dioxide, nitrogen oxides and water.
5. Major sources of sulphur dioxide and nitrogen oxides are coal-burning generating stations, iron and nickel smelters and vehicle exhausts.
6. Acid precipitation deposits occur in two forms: wet (such as rain, snow, hail and sleet) and dry (such as dust).
7. Acid rain affects aquatic, terrestrial and human environments.
8. In Canada, steps are being taken to combat problems caused by acid rain.

BACKGROUND INFORMATION

The pH Scale

Acid levels of solutions are measured in pH units on a scale of 0 to 14. A pH of 7.0 is neutral (neither acid nor alkaline).

The lower the number, the more acidic the solution is. The higher the number, the more alkaline the solution is.

Small changes in number represent large changes in content. For example, a lake with a pH of 6.0 is ten times more acid than a lake with a pH of 7.0.

Pure water in equilibrium with carbon dioxide in the atmosphere has a pH of about 5.6. In the absence of other chemical influences, therefore, normal rainfall will have a pH value of 5.6.

A drop from pH 6.0 to pH 5.5 will cause the decline in the numbers and types of organisms in the lake. The organisms which do survive may experience problems.

A drop from pH 5.5 to pH 5.0 will eliminate some species and reduce the populations of survivors such as crustaceans, zooplankton, watermites, algae, snails, clams, crawfish, frogs, salamanders, freshwater shrimp, fairy shrimp, most mayfly species and many stonefly species. Some bottom dwellers (such as midges, bloodworms and other worms) and some chitinous insects (such as backswimmers, whirligig beetles and water boatmen), however, will increase in numbers.

A drop from pH 5.0 to pH 4.5 will cause further deaths. Also, the natural decay of dead plants and animal matter will cause a build-up of humus, waste and debris. At this point, most fish species will have died. Aquatic larvae or flying insects (such as dragonfly, damselfly, alderfly, fishfly and caddisfly), however, are able to survive these highly acidic waters.

At a pH below 4.5, all fish and most other aquatic life die.

How Acid Rain Forms

Emission

Normal rainwater is slightly acidic due to the presence of carbon dioxide dissolving to form carbonic acid. Ore-smelting, coal- and oil-burning industrial furnaces and petroleum refining all emit sulphur dioxide, thus making rain abnormally acidic. Vehicle exhausts and fossil-fueled power plants contribute emissions of nitrogen pollution.

Transportation and Conversion

Sulphur dioxide and nitrogen oxides are carried by prevailing winds over distances up to thousands of kilometres. For example, about 50% of the emissions which affect Ontario, for

AQUATIC HABITAT

This study will raise awareness of the complex and diverse relationships that exist within aquatic communities.

OBJECTIVES

1. To develop an understanding and appreciation of the aquatic environment.
2. To develop skills in sampling for animals and plants.
3. To develop skills in measuring physical parameters, such as water velocity and temperature.

CONCEPTS

1. There is a broad diversity of life in any body of fresh water.
2. These various life forms occur whether the body of water is large, small, temporary or permanent.
3. The population of the aquatic community is made up of interacting, interdependent plant and animal species.
4. The variety and quantity of plants and animals in the aquatic environment reflect the physical characteristics and quality of that environment.

BACKGROUND INFORMATION .

Aquatic Communities

Aquatic communities can be divided into two broad groups: quiescent water (such as ponds, lakes and swamps) and running water (such as rivers, creeks and streams). Factors that affect the type and diversity of organisms in the community are water velocity, temperature and clarity.

High Velocity

Organisms living in fast-flowing water areas must find ways to prevent being swept away by the current. The blackfly and riffle beetle larvae use the sucker-like structures on their ventral surfaces to secure themselves to rocks or other sound surfaces. The nymphs of stonefly and mayfly use their flattened, streamlined shape to adhere to the underside of rocks. Some plans use strong, sturdy roots and thin stems and leaves to avoid being broken and swept away by the current.

Fast-moving streams also have an abundant supply of oxygen because the water tumbling over the rocks absorbs oxygen from the air. Thus, organisms living in fast-moving water are usually those which require high oxygen levels or which have adapted to tolerate them.

Low Velocity

Organisms living in slow-moving water areas must cope with low oxygen levels and the threat of being buried by particles of sediment settling to the bottom. The tubeworm's wriggling case deals with both problems. The wriggling action increases the amount of water with which it comes into contact (and also, therefore, the amount of oxygen), and the case sticks up above the sediment at the bottom of the stream, thus preventing the tubeworm from being buried.

Temperature and Stratification

As water temperature varies with the season, it poses different challenges to organisms living in the stream.

In spring, lake water tends to be cold. This enables it to absorb a lot of oxygen from the atmosphere, which makes breathing easier for fish.

In summer, the sun warms the upper layer of the water more quickly than the wind can mix it with the lower layers. Since the warmer water is less dense, it tends to remain on top, creating two distinct layers. Eventually, water currents form three distinct layers: an upper, warmer, freely-moving layer; a transitional layer; and a cooler, lower layer, which does not receive any atmospheric gases.

In fall, the surface water cools and is mixed, top to bottom, until the entire body of water is, again, of uniform temperature.

In winter, the upper layer cools, becoming more dense and sinking to the bottom. This process continues until the colder water reaches a temperature of 4°C (39°F). Water colder than this stays near the surface and eventually freezes.

AQUATIC HABITAT

The temperatures and dissolved oxygen become uniform again when spring arrives and the ice breaks up.

Throughout this seasonal cycle, the water temperature plays an important role in regulating the chemical and biological processes of the organisms living in the water.

Transparency and Turbidity

Transparency refers to the clarity of water. When substances such as soil, chemicals, bacteria and plant life form small particles and mix in the water or remain suspended in it without dissolving, the water may become turbid, or muddy-looking.

Water may look turbid but not be polluted. Conversely, water may look transparent but still be polluted.

One way of measuring the pollution of a body of water is to evaluate the quantity and quality of the species living in it. As pollution increases, some species also increase while others decrease or disappear.

Species diversity tends to decrease in a polluted environment. This is because the chemical and physical characteristics tend to be so restrictive that only a few species can survive. The numbers of any species which can survive may increase, however, if the pollutant is a non-toxic organic which produces a rich food source for that species.

AQUATIC HABITAT ACTIVITIES

Before You Start

1. When choosing a field site (pond, stream, lake or swamp), look for these characteristics:
   - A reasonably firm footing so that participants may wade into the area safely. (Wading in helps participants develop better understanding of the environment.)
   - A shallow with a gently sloping shore large enough to accommodate the entire group.
   - Two or more types of communities, such as a stream draining a pond. (This is ideal for programs involving comparisons of aquatic communities.)
2. Plan on a minimum of two hours for this study (one hour in the field and one hour for preparation and follow-up). You should, however, also take these factors into account:
   - How many parameters do you wish participants to measure?
   - How old are the participants?
   - Enthusiasm tends to run high in the field. It may be difficult to maintain time limits.
3. Dress for the weather and the site. Participants should wear clothes that will not be damaged by becoming wet. (T-shirts, shorts and running shoes are often a good choice for warm days. Windbreakers, jeans and rubber boots may be a good choice for cooler or rainy days.)
4. Introduce or review water safety rules before all field trips.
5. Introduce or review the concept of appreciation and care of the environment before all field trips. For example:
   - Return all specimens to the water as closely as possible to the site where they were found.
   - Turn overturned rocks right side up.
   - Plants needed for observation should be pulled up by the roots and replanted when finished with the study.
6. Before and after field trips, discuss techniques for measuring and proving observations. Encourage participants to develop new techniques or to adapt known techniques for new uses.
7. Collect and prepare the equipment you will need in advance. Typical aquatic habitat study activities require this equipment:

- Plastic pails, with or without handles (such as litre-size ice cream, fruit and honey containers).
- Sorting trays (such as dishpans; aquatic organisms show up well against white or light-colored backgrounds).
- Magnifying lenses.
- Eyedroppers and basters.
- Collecting nets (such as plankton and minnow nets and butterfly nets, which are available in toy stores).
- Hand dip nets with a circular frame for attaching a net bag (used mainly for collecting insects and other small aquatic life on the surface of the water, among plants, and under stones and logs along the shore).
- Flat-bottomed nets for collecting larger aquatic organisms throughout the water column. (For instructions, see Things to Make on this page)
- Spoons or hand trowels.
- Bottom trawlers or screeners (such as kitchen sieves or strainers with the ends snipped off so that they do not snag debris).
- A hand screen for washing bottom samples. (For instructions, see Things to Make below.)
- Thermometer (one per instructor).
- Metre sticks or tape measures.
- Field guide with a general identification key (one per participant or group if working in units).

Things to Make

1. This is how to make a flat-bottomed net.
    - Bend a wire coat hanger into a D-shaped frame about 35 cm in diameter.
    - Make a net bag, about 60 cm deep, from cheesecloth, window screening wire, panty hose or nylon stockings or 3 mm mesh netting.
    - Sew the bag onto the frame.
    - Attach a pole handle, up to 90 cm long, to the frame with strong tape. (A broom handle or hockey stick is ideal.) .
2. This is how to make a hand screen.
    - Build a frame with pieces of wood about 3 cm long.
    - Tack on a 1 mm (or less) mesh screen. This will let finer particles wash through. (Remove large stones by hand.)
3. If possible, construct a closed ecosystem so that participants may observe the intricate workings of an interacting community over a long period of time. This will be particularly useful for developing basic ecological concepts (such as the need for sunlight, how oxygen is produced, etc.). This is how to build a miniature closed ecosystem.
    - Get a large bottle, preferably one with a lid or stopper. Clean it well, and rinse it with clean water.
    - Locate a slow-flowing pond, lake shore or stream where aquatic plants are growing. (This is likely to yield a variety of plant and animal aquatic life.) Scoop about 5 cm to 8 cm of bottom sediment into the bottle.
    - Use a sieve or net to catch tiny aquatic organisms that may be living around the plants. Place them in the bottle.
    - Fill the bottle to the three-quarter level with water obtained at the site.
    - Put the bottle on a window sill or ledge out of direct sunlight (otherwise, the temperature will get too high).
    - If aquatic plants were not available at the site, get some from a local tropical fish store. (Elodea, or Canada Water Weed, is a good choice.) Insert them into the bottle carefully. Secure them

in the sediment by tying them to weights, such as small stones, if necessary.

- If snails were not obtained at the site, get some of these elsewhere as well and add them to the bottle.
- Put a lid on the bottle, but do not seal it.
- After several weeks, the system should be functioning in some sort of balance. If it is, make the seal air-tight by applying melted paraffin wax around the lid or stopper.

4. Participants may find an aquatic field study worksheet helpful for guiding and recording observations. See page 22 for samples.
5. Participants may find an aquatic animal habitat worksheet helpful for guiding and recording observations. See pages 19 to 21 for samples.
6. Participants may find an aquatic study information sheet helpful. See pages 23 and 24 for samples.

How to Measure the Speed of Water

1. Measure the distance in metres along the shore between two points.
   - Point A is upstream (start).
   - Point B is downstream (finish).
2. Mark Point A and Point B.
3. Put a floating object into the water at Point A.
4. How long does it take for the object to reach Point B?

   Measure the time in seconds.
5. Use this formula to determine the speed of the water.

   Fill in the blanks with your measurements.

$$\text{Speed of Water} = \frac{\text{Distance Travelled (in metres)}}{\text{Time (in seconds)}}$$

$$= \underline{\qquad}\ \text{m}/\underline{\qquad}\ \text{s}$$

AQUATIC HABITAT WORKSHEET

What does it look like? (Draw a sketch.)	What color is it?	How long is it?	What shape is it? Is it round, oval, flat, skinny, irregular, rectangular, cylindrical?

AQUATIC HABITAT WORKSHEET CONTINUED

How does it move? Does it crawl, slither, swim forward, swim backward, walk?	Where did you find it? Was it in the mud, under a rock, on the floor, in the water, on top of the water?	What features does it have that allows it to live where it does?

AQUATIC FIELD STUDY WORKSHEET

The Floor

Color	0	1	2	3	4	5	Describe the color.
	Light					Dark	____________________
							____________________
Texture	0	1	2	3	4	5	How does it feel?
	Squishy					Solid	____________________
							____________________
Smell	0	1	2	3	4	5	Describe the odor.
	Mild					Rich	____________________
							____________________
Composition	0	1	2	3	4	5	Of what is it made?
	Plants,					Sand,	____________________
							____________________
	muck					gravel	
Which plants and animals will live there?							____________________
							____________________
							____________________

The Water

Clarity	0	1	2	3	4	5	Can you see the floor? ______
	Murky					Clear	How well? ____________
Color	0	1	2	3	4	5	Describe the color.
	Light					Dark	____________________
							____________________
Temperature	0	1	2	3	4	5	What is the temperature? ____
	Cool					Warm	
Smell	0	1	2	3	4	5	Describe the odor.
	None					Strong	____________________
							____________________
Speed	0	1	2	3	4	5	What is the speed of the water?
	Still					Fast	____________________

AQUATIC STUDY INFORMATION SHEET

The Life in a Typical Stream

Characteristics

Bedrock	Rubble or Gravel	Sandy	Mud or Silt
Little food or protection	High water speed Ample supply of food and oxygen	No solid rooting for higher plants No smooth surfaces for plant attachments	Abundant rooting Same characteristics as pond

Plant Life

Bedrock	Rubble or Gravel	Sandy	Mud or Silt
Blue-green algae Fountain mosses (perhaps)	Blue-green algae Fountain mosses Diatoms Water hypnum Elodea		Diatoms Algae Fountain mosses Hornwort Pickerel weed Water weed Burreed Arrowhead Watercress Duckweed

Continued on next page

AQUATIC STUDY INFORMATION SHEET CONTINUED

Animal Life			
Bedrock	Rubble or Gravel	Sandy	Mud or Silt
Nematodes Nymphs of mayfly (Limited food supply limits animal life)	Nematodes Bristleworms Planaria Larvae of sponge Bryozoans Cranefly Midge Blackfly Caddisfly Riffle beetle Mayfly(nymph) Stonefly Dragonfly Water strider Snails Clams Leech Trout Minnow	Planaria Nematodes Mayflies Cadddisflies Alderflies	Rotifers Copepods Protozoans Nematodes Tubifex Bristleworms Bryozoans Mayfly(nymph) Dragonfly (nymph) Caddis worms Midge larvae Amphipods Crayfish Leeches Waterstriders Clams Suckers Catfish Northern pike Yellow perch

AQUATIC HABITAT

Activity 1: Water Stories

Read aloud stories about ponds or lakes. Encourage participants to tell stories about personal experiences in or around ponds or lakes. What did they see and hear?

Activity 2: Water Pictures

Collect pictures of ponds cut from magazines and newspapers. Use these as a resource for drawing or making a picture of "typical" pond. Discuss what does and doesn't belong.

Activity 3: Stream Means

In discussion, develop the concept that a stream is an entire community that includes plants and animals in and around the stream as well as on the water bed and banks.

Follow up with a discussion after a field trip. Has this definition of stream been confirmed or changed? How? Why?

Activity 4: Aquatic Floor

Examine the water bed. Observe, measure, and record.

1. What color is the floor?
2. What does the floor smell like?
3. Of what is the floor made?
4. What color is the water?
5. What is the temperature of the water?
6. How fast is the water flowing? (Measure the speed, or velocity, in metres per second.)

Activity 5: Surface Currents

Discover the velocity of the surface current. Measure off a distance with a measuring stick or tape. Drop a visible, floating article (such as a brightly colored ball, fishing bobber or stick) into the stream at the starting point. Measure the time it takes to travel the measured distance.

Activity 6: Water Temperature

Measure and record the water temperature at various depths in the pond or stream. Graph and discuss the results.

Activity 7: Slow and Riffle Water

Develop an awareness by comparing a pond, or slow-flowing, aquatic community with a riffle, or fast-flowing, aquatic community.

An effective way to do this is to divide participants into two groups. Both groups should collect and examine organisms in order to determine how they are adapted to their environment. The groups should then discuss and compare results.

Activity 8: Aquatic Changes

Develop awareness of the aquatic environment as a changing one. Discover, measure, and record.

1. Something that is increasing in number.
2. Something that is decreasing in number.
3. Indirect evidence of another population.
4. A good change and a bad change (and why).
5. A predictable change.
6. A predator and its prey.

Activity 9: Aquatic Awareness

Develop awareness of the textures and qualities of the aquatic community. Discover, observe and record.

1. Find an object that is hard or soft.
2. Find an object that is big or small.
3. Find an object that is high or low.
4. Find an object that is ugly or beautiful.
5. Find a water column.
6. Find the oldest thing around the pond.
7. Find something that makes you feel good.
8. Find something that makes you feel sad.
9. Find something that makes you feel angry.
10. Find something that is useful to you.

AQUATIC HABITAT

Activity 10: Aquatic Expressions

After a field trip, draw pictures about the experience. Participants could draw things they found particularly interesting or attractive or of the site itself. Encourage participants to use accurate colors and details.

Activity 11: Water Use

Collect and discuss pictures that show how water is used in the participants' community.

Activity 12: What Is X?

Play pond add and subtract with these teasers. (For answers, see parentheses.)

X = tin + aspects - tap

(X = insects)

X = from + cat + gill - cat - mill

(X = frog)

X = moss + quite + pot - step + am - o - am + boat - bat

(X = mosquito)

X = snake + gilled - keg - led

(X = snail)

X = tame + addition + pole - am - edition

(X = tadpole)

X = wait - it + tea + rat - a - at

(X = water)

Activity 13: Clean Up

How could a dirty stream be made clean again? Discuss and develop procedures.

Activity 14: Populations

Compare and discuss the populations in various areas of the aquatic community. For example, how many specimens were adult? How many were in the riffle, or fast-moving, section? How many live on the bottom? Do you think this ratio will be the same during every season of the year? How might it change? Why?

Activity 15: Species Study

Select one species in the aquatic community and conduct a population study. For example, count the number of crayfish found in a metre-square area or during a three-minute period.

Activity 16: Food Chain

Using the organisms found in a stream or pond, develop an understanding of the food chain or food web likely to apply to the aquatic community.

Activity 17: Hydrologic Cycle

Study the hydrologic cycle in the aquatic community. From where does its water come and where does it go? Extend the study to the hydrologic cycle in the participants' community.

Activity 18: Ecosystem Experiments

1. Observe the closed ecosystem. Over time, become aware of its complexity and the cyclical patterns of life within it.
2. Illustrate other ecosystems by setting up experiments using other bottles. For example, add or subtract components (such as minnows or sediment). Using the main ecosystem as the control, observe how each component is important to the balance which is eventually established.
3. If the ecosystem has not been sealed and chemical testing is available, test the chemical nature of the water on a daily or weekly basis. Determine oxygen, carbon dioxide, and pH levels. Graph over an extended period in order to see what changes are occurring.

INSECTS

Insects are the most numerous creatures on Earth. Over a million species have been documented, but this may represent only a fraction of the number which actually exist. (One estimate is that there are over 10 million insect species.)

So, everyone has had some experience with insects. Most people are also fascinated by their small size, delicate shape, bright colors and interesting habits.

This study will help participants appreciate the unique features of some insects.

OBJECTIVES

1. To develop an understanding and appreciation of insects.
2. To examine the diversity of appearance in insects.
3. To relate differences in appearance to insect habitat.

CONCEPTS

1. An insect is defined by specific characteristics that appear during stages of development in its life cycle.
2. Insects are found everywhere.
3. Insects have individual characteristics that allow them to survive in the habitat in which they live.

BACKGROUND INFORMATION

Insect Characteristics

The insect body is divided into three parts: head, thorax and abdomen.

The thorax has three segments, each with a pair of jointed legs attached. Thus, the insect normally has six legs.

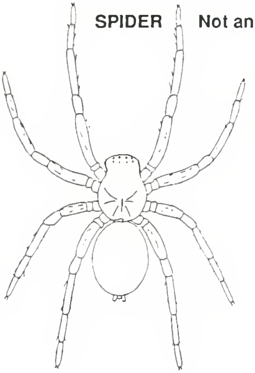
Most insects have two pairs of wings attached to the thorax. Some have only one pair, however, and a few have no wings.

Insects usually have two sets of jaws, two types of eyes (simple and compound) and one pair of antennae.

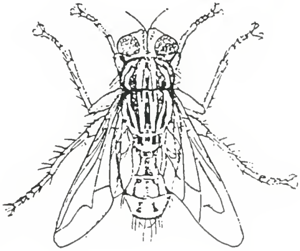
The insect wears its skeleton on the outside of its body. This is called the exoskeleton.

Sometimes, insects are difficult to identify. For example, in some insects, the thorax and abdomen appear to run together. Others are worm-like in their immature (larval) forms.

SPIDER Not an insect



FLY – An insect



INSECTS

What Is and Isn't an Insect

Many insect-like animals are confused with insects.

Spiders are not insects. They have only two body divisions, four pairs of legs and no antennae.

Centipedes and millipedes are not insects. Both have antennae (long in centipedes and short in millipedes). However, both also have many body segments with one pair of legs (centipedes) or two pairs of legs (millipedes) attached to each segment.

Insect Life Cycles

Most insects start life as an egg laid on a leaf, tree branch, living animal, flower, plant stem, fruit, root, rotting carcass, ground or water. They mature in different ways, however.

One type is hatched as a miniature adult. It grows and moults (sheds its skin) until it reaches adult size.

Another type matures through incomplete metamorphosis. The immature nymph is hatched from the egg, grows, develops wings and becomes an adult in stages.

The third way is complete metamorphosis. This involves four distinct phases: egg, larva, pupa and adult.

Sensory Awareness

Insects see, hear and smell in different ways.

Insects can perceive mass, motion, light and color. What they see depends on the construction of the eyes. Bees, for example, see little of what humans see. But bees can see beyond the human spectrum and perceive many plant colors that are invisible to human eyes.

Adult insects have two compound eyes, one on each side of the head. These compound eyes are made up of many tiny eyes set close together like a honeycomb. Each compound eye is divided into six-sided areas called facets. Ants and other ground-living insects have only a few facets. Dragonflies and other species may have thousands of facets. The more facets, the sharper the insect's vision will be.

Insects' hearing equipment is located in different parts of the body, depending on the species. The grasshopper has an oval membrane sensitive to sound on the side of the first abdominal segment. The cricket and ant have hearing organs on their front legs. The male mosquito hears through its antennae.

Insects' antennae are attached to the head in front of or between the eyes. Their shape and complexity varies according to the species. They are used to investigate the surroundings. In many species, antennae are also related to the sense of smell.

Winter

Many adult insects hibernate under logs and rocks or in weed clumps, grass turfs, crevices and among fallen litter.

Adult flies die but leave their offspring (in larvae, pupae and egg stages) in piles of decaying plants and manure. In spring, new batches of adult flies quickly appear.

Ants hibernate in underground tunnels.

Before adult female cicadas die, they bore holes in twigs of trees and lay their eggs. In about six weeks, the young hatch, drop to the ground, dig in and attach themselves to tree roots. Some species of cicada nymphs stay in the ground from two to five years. Others stay as long as 17 a (years).

Butterflies cope in different ways. Some hibernate, some die after laying their eggs, and some, such as the Monarch, migrate.

Some adult female mosquitoes winter in logs, caves and water courses. Their eggs lie dormant through winter.

Each female cricket lays as many as 300 tiny, banana-shaped eggs in the ground before she dies. The adult male also dies.

The female grasshopper digs a hole in the ground where she lays from two to 120 eggs, covering them with a special waterproof juice. The adults die. Only the queen of the wasp and bumblebee lives underground until spring. All others die.

Honeybees survive in a unique way. When the temperature falls below 13°C, the worker bees form a thick ball in the hive. They keep moving slowly about in this ball shape so that those in the warm centre move out and those in the cold outer sections move in. They live on the stored honey.

Ladybird beetles, sometimes called ladybugs, hibernate in haystacks and forest logs, under leaves, among rocks or under loose sidings of buildings. On warm days, they may wake up, make a flight and then return to sleep.

INSECT ACTIVITIES

Before You Start

1. Insects can be found in soil, trees, air, ground, vegetation and water. The ideal field site will have a forested or bushy area, an uncut field section and a pond. The site should also be within convenient reach so that travel time and costs are limited.
2. Dress for the weather and the site. Participants should wear clothes that are suitable for hands-on, outdoor activities. In most cases, outdoor clothing and running shoes are appropriate.
3. Collect and prepare the equipment you will need in advance. Typical insect study activities require this equipment:
   - Collecting nets (such as butterfly nets, which are available in toy stores) or flat-bottomed nets. (For instructions, see Things to Make starting on this page.)
   - Containers of various sizes. (Examples are Petri dishes, magnifying boxes, and clear glass jars of various sizes.)
   - A large sheet (preferably old, soft cloth) to lay out under trees and shrubs (to catch insects as the vegetation is shaken gently). .
   - Spoons or hand trowels for collections from soil. Note, however, that collecting with hands is both safer for the insects and a better learning experience for participants.
   - Magnifying lenses.
4. Before and after field trips, discuss such topics as:
   - Where insects are found.
   - The major life cycles of insects.
   - Identifying insects and distinguishing them from other similar animals.
   - The difference between insects and bugs.
   - The effect of adaptation and modification on insect populations.
   - The role of insects in the natural and human environment.
5. Introduce or review the concept of appreciation and care of the environment before all field trips. For example:
   - Collect with care. Do not change the environment any more than absolutely necessary.
   - Return all specimens as closely as possible to the site where they were found.
   - Do your best to return the environment to the state in which you found it.

Things to Make

1. This is how to make a flat-bottomed, insect-collecting net.
   - Bend a wire coat hanger into a circular frame about 30 cm in diameter.
   - Make a net bag, about 50 cm deep, from cheesecloth, window screening wire, panty hose or nylon stockings or 3 mm mesh netting.
   - Sew the bag onto the frame.
   - Attach a pole handle, up to 75 cm long, to the frame with strong tape. (A broom handle or hockey stick is ideal.)

2. This is how to make an external light source for study of nocturnal insects.

INSECTS

- Use extension cords to string a light bulb or lamp outside.
- Cover the light with a white sheet.

3. This is how to make an insect zoo.
    - Cut a plastic bottle (such as a vinegar or fabric softener container) crosswise about one-quarter to one-third from the top.
    - Make a tube window screen about 30 cm to 40 cm high. Set it into the bottom half of the bottle.
    - Arrange soil, plants, or twigs in the bottom so that insects may climb and feed.
    - Put the top back on so that the insects cannot escape. (When necessary, extra food can be dropped through the top.)
4. This is how to make a mealworm culture.
    - Clean and dry an aquarium.
    - Put about 750 mL to 1000 mL of oatmeal and half an apple into the aquarium.
    - Add a supply of mealworms (may be obtained from a biology supply house).
    - Wait several weeks as the mealworms feed on the oatmeal. Metamorphosis will occur. It should be possible to observe all stages (egg, larva, pupa, adult).
    - Change the oatmeal at about the six-month mark.
5. This is how to make an ant farm.
    - Fill a clear glass jar or aquarium with soil and ants collected from a natural anthill.
    - Cover the glass with dark paper so that the ants will tunnel and lay eggs against the glass.
    - Wait several weeks, then remove the paper.

Activity 1: Insect Search

After discussing where insects are found, groups of participants should collect insects from one of the four major "homes" (soil, trees and shrubs, air and water). Encourage participants to collect one specimen of each kind of insect they find in the assigned "home" area.

Activity 2: Insect Picture

Draw a detailed picture of one or more insect specimen. Participants should use blank sheets of paper and magnifying lenses. If possible, they should also identify and name the insect, but this should not be stressed until a later stage.

Activity 3: Insect Observation

Watch the insects. Over a period of several minutes, participants should observe and record an insect specimen's features and behavior. Use these questions as guidelines.

Fly: How many wings does it have? What color are the wings? How many legs does it have? Where are the eyes? What color are the eyes? What kind of noise does it make? Where is its mouth?

Ladybird beetle: Can it fly? How many spots does it have? Does each ladybird beetle have the same number of spots? How long are its legs? Where was it found? What kind of plant was it on?

Butterfly: Are the wings smooth and shiny or fuzzy and rough? Where are its legs? How long is its body? How wide are its wings?

Leafhopper: Are all its legs the same length? Why? How many different colors are there on its body? What shape is its head? How far can it jump?

Carpenter ant: How does it hold food and move at the same time? How many parts does its body have? Does it have feet? How long are its antennae? Does it have wings? Why?

INSECTS

Activity 4: Insect Adaptation

Compare the insect specimens. How is each adapted to live in its habitat? Consider means of locomotion, flight, coloration, size and mouth parts. (For example, flying insects may have larger and more obvious wings than insects found under rocks.) Speculate about behaviors as well. (How will the insect find its food? How will it escape from danger?)

Activity 5: Insect Food

What do insects eat? What else, other than food, might attract them? Experiment with placing food or scented materials in various locations. Observe and record the results.

Another approach is to prepare and place a significant food supply in one location and use it as a long-term observation post. Empty and clean a tin can or similar container, sink it (top removed) into the ground and put food bait inside (sugar, honey, jam, rotting meat or fruit). Cover the can with a rock or piece of wood, allowing air space. Check the can regularly to see which insects have been attracted.

Activity 6: Insect Art

Develop an image of an imaginary insect, keeping in mind the six basic characteristics (legs, three body parts, wings, exoskeleton, compound eyes and antennae). Encourage participants to present an imaginary insect's life through stories, pictures and models (using such materials as wooden sticks, styrofoam, and other craft supplies).

Activity 7: Insect Clues

What evidence may insects leave behind? How might you discover the presence of insects when the insects themselves are not there? Look for evidence of insect activity. Examples are eggs from the spittle bug, galls on goldenrod, cocoons in tree bark and insect homes (such as a wasp's nest or ant hill).

Activity 8: "It" Day

Dedicate one field trip to observing one particular type of insect or related animal. (Examples are ants, grasshoppers, caterpillars, butterflies, bees, houseflies, ladybird beetles, snails, spiders, etc.) Observe the insect type's interesting behaviors in the field as much as possible. If collecting is done, keep the specimens only a short time before returning them to their natural habitat.

Activity 9: Insect Learning

Build a maze and put an ant in it. How long does it take the ant to find the food? Does the ant find the food faster on the second or third try?

Activity 10: Crawlers

Locate and observe a crawling insect in its natural habitat. How does it move? How quickly does it move? Where does it live? Where does it eat?

Activity 11: Good and Bad

Discuss the role of insects in the environment. Consider helpful roles, such as pollinating, producing food (for example, honey), acting as a food source for plants and other animals, controlling weed growth (for example, the alligator weed beetle) and controlling other insects (for example, dragonflies eating mosquitoes).

As well, consider harmful roles, such as destroying crops, spreading disease and acting as a pest (for example, mosquitoes and blackflies are a pest to humans).

INSECTS

Discuss the question of insects and human society. Could human society exist without insects?

Activity 12: Insect Control

Visit a local orchard or farm to find out how insects are controlled. What means are used? If insecticides and pesticides are used, how are they applied and how often? What are the advantages and disadvantages of each method of control?

Activity 13: Nocturnal Insects

How are nocturnal insects adapted to their habitat? Discuss and experiment with light, color, and scent.

1. Set up an external light (see Things to Make, page 29) with a clear bulb. After an hour, look at the creatures that have landed on the sheet. Change the bulb to other colors, such as red, blue and yellow, waiting an hour each time. Which colors attract insects? Which do not?
2. Some insects make their own light and use it to communicate. Male fireflies, for example, "talk" to females by flashing lights. Different firefly species use different codes. Observe how different nocturnal insects use lights. Use a penlight to experiment with "talking" to insects.
3. Scent attracts some insects. Many flowers, such as honeysuckles and evening primrose, have very strong evening perfumes for this purpose. Experiment with various scents. Mix solutions (using distinctive base substances such as vinegar, honey, lemon juice, rubbing alcohol and raw meat) and place samples in various locations. Count the number of insect visitors over 30 min. Which scents are the most attractive?

Activity 14: Insect Count

Survey several different areas for types of insects found. Record observations and counts on a chart or graph.

Activity 15: Insects Close Up

Make an insect zoo, mealworm culture and ant farm. (See Things to Make, page 29.) Observe and record the behaviors and life cycles over several weeks or months.

Activity 16: Wasps

Collect goldenrod galls and put them in a clear glass jar. Cover the jar with netting (panty hose or wire mesh). Observe and record over a period of weeks. Eventually, the adult wasps will emerge.

Activity 17: Insect Classification

Identify and classify the insect specimens which have been collected and observed.

Activity 18: Insect Eating Habits

1. Prepare the food. Collect three or four dead leaves from these five different categories of trees: black elm, hornbeam; alder, ash, elm; spruce, beech, red oak, pine, Douglas fir, larch; basswood, maple; and oak, birch, aspen.
2. Prepare the soil. Collect five samples from five different locations. Mark the locations on a map. Place the soil samples in separate plastic trays.
3. Prepare the insects. Collect about 10 sow bugs. Put two sow bugs and a leaf from a different category on each soil sample.
4. Observe over a period of time. Which leaves are eaten first? Do eating patterns differ according to the leaves? How much is eaten each day? (Draw pictures using different colors to indicate the quantity eaten.)

NATURE

Experiencing nature during the different seasons of the year develops a special sensitivity to the interactions of life in the natural environment.

OBJECTIVES

1. To develop an understanding and appreciation of nature as a whole and the natural environment.
2. To provide an opportunity to develop the imagination and senses.
3. To develop an appreciation for the relationships, interactions and delicate balances involved.
4. To develop identification skills.

CONCEPTS

1. Nature has incorporated minute detail in the construction of all things.
2. The complexity of living things is mirrored in the complexity and delicacy of relationships in the natural environment.
3. Everything changes with time, including the natural environment.

BACKGROUND INFORMATION

The Ecosystem

An ecosystem consists of groups of organisms (living creatures) and their physical (non-living) environment. This includes plants, animals, soil, water, air, light, wind and temperature. Examples of ecosystems are lakes, ponds, forests, oceans and the world as a whole.

Survival of the ecosystem depends on the interaction of its components. For example, plants provide food for some species of animals. These animals become food for other animals. Temperature, precipitation and soil determine the quantity and quality of plants available.

Animals are called consumers because they use the oxygen produced by plants and feed on the plants directly (if herbivores) or indirectly (if carnivores).

Some animals play more than one role. Snails, for example, are decomposers as well as consumers. They, together with yeast, bacteria and fungi (most decomposers are microscopic creatures), work to break down dead material and return it to the soil.

Succession

Succession refers to the natural process by which one type of vegetation is taken over by another. Vegetation is always changing. Whenever land is cleared by natural or human means, it will not stay barren for long. Soon, plants able to withstand harsh conditions of bright sunlight and poor soil nutrients will spring up. They will be followed by other plants as the process moves from pioneers to shrubs to climax plants.

Pioneer Plants

Algae, bacteria and lichens are the first pioneer plants to take hold. They can survive where other plants cannot. As they die, they enrich the soil, preparing it for later stages of succession.

Moss is a more advanced pioneer plant. Individually, each plant is small, but moss grows in such quantities that the overall effect is large.

As the soil becomes richer, fast-travelling seeds of annual grasses and weeds, such as goldenrod, take root in the lichen and moss environment. The grasses and weeds will increase the soil's ability to hold water, an important factor in plant growth.

After three or four years, perennial plants will begin to grow. Earlier arrivals will have not been able to survive. Later arrivals will find more supportive conditions. In turn, they will add nutrients to the soil and aid the development of future growth.

Shrub Plants

Longer-living plants and improved soil provide perches for birds, which help with seed dispersal. Shrubby trees which need a lot of sun (such as cherry, sumac, willow, aspen and evergreen) begin to grow.

NATURE

Climax Plants

As the shrub trees mature and cast shade, their seedlings give way to the seedlings of plants which can grow in shaded conditions. Oaks, maples, beeches and other hardwoods take their turn.

The shade-tolerant trees and plants remain until a significant change in the physical environment forces the community into a different stage of growth. For example, a forest fire started by lightning may destroy all the growth over a wide area, leaving the ground open for lichens and moss again.

Natural Communities

There are many different types of natural communities. Field and forest will be discussed here. Their vegetation, animal life and physical factors provide some insight into the interactions occurring in natural environments.

Field

Organisms in open areas must be able to withstand harsh conditions (high winds, extremes in temperature, dramatic changes in light from day to night and periods of flood and drought).

In old fields, there is usually a variety of wildflowers because there is sufficient sunlight to provide energy for the plants to grow, produce flowers and release seeds, even if the summer period is quite short.

Pollination by wind or insects is common. Colorful flowers and sweet-smelling nectar attract insects to plants. The relationship is mutually beneficial. The insects receive food, and the survival of the plants is ensured. As the insects move from plant to plant, they transfer pollen from stamens to pistils.

Plants pollinated by wind do not need colors or scents to attract attention. What they do need are long, protruding stamens with an abundant load of pollen. (Grass is an example.) This fine, flexible structure allows the plant to bend with the wind and rub against adjacent plants, transferring pollen.

Plant seeds are usually dispersed by wind or animals. Wind-dispersed seeds, such as dandelion seeds, tend to be spread over a larger area than animal-dispersed seeds, such as burrs which hook onto an animal's hide.

Dry conditions and daily temperature fluctuations are part of life in an old field. The plants develop different ways of adapting to this environment. For example, some have thick waxy coatings on their leaves or stems to reduce water loss. Some have hairs on the leaves or stems. This reduces water loss by creating a dead air space, or insulating layer. (Milkweed is an example.)

In succession terms, the plants of an old field are often referred to as pioneer species. This means that they are the first to establish themselves in a recently disturbed area. Examples of pioneer species are goldenrod, fireweed and common mullein.

Forest

In deciduous and coniferous forests, perennials will be more common than wildflowers. This is because forest floors receive less sunlight than open fields.

Trees and other forest plants usually flower early in spring before the tree leaves appear. This allows the plants on the forest floor to receive enough energy from the sun to support reproduction. It also allows wind pollination to occur. For example, maple tree flowers come out in spring before the leaves. This allows the wind to spread pollen from the male flowers, which fertilize the female flowers. By fall, the seeds are ready to be dispersed.

Tree seeds are dispersed by wind and animals. Seeds of smaller forest plants are dispersed by animals. Most forest plant seeds require longer germination periods because they receive less sunlight than field plant seeds. Also, forest plant seeds are often larger so that they may contain a larger food reserve. (An example is the acorn.)

The forest environment is less harsh for plants and animals because the forest canopy provides protection. Temperature fluctuations and droughts are less severe. The physical stress therefore is less severe. The cool shade also provides the ideal habitat for moss and fungi growth. Fungi are useful for breaking down dead vegetation, returning the nutrients to the soil.

Soil conditions are unique in forests. Only organisms which can tolerate acidic soil can live in coniferous forests, for example. Pine needles decompose to form a very acidic soil. The climax stage in succession is a self-perpetuating forest. An example is a beech and maple forest in central Ontario.

NATURE ACTIVITIES .

Before You Start

1. The ideal site is a field with an adjoining forested or bushy area. It should also be within convenient reach so that travel time and costs are limited.
2. Hike over the area before the field trip. Familiarize yourself with the terrain and identify sections where special care is needed or which should be avoided (swamps, very dense shrubs and bush, etc.).
3. Choose a day which is pleasant but not too warm or cold. Also, avoid hikes around mid-day when the sun is at its hottest.
4. Dress for the weather and the site. In most cases, outdoor clothing and running shoes are appropriate. Remind participants how important it is to protect the feet. (Discourage open sandals and thongs.)
5. The ideal leader is a person with enthusiasm and sensitivity to the environment. Being able to rhyme off names of animals, plants, trees, birds and insects is not essential. The main goal is to encourage enjoyment, observations and insights. Provide field guides and encourage their use, but do not tie the experience to step-by-step identifications.
6. A good technique is frequent, short stops to attract the group's attention and interest. Point out features of the world in which they live. Examples are well-known trees, plants, insects, unusual patterns or designs in tree bark, animal homes, birds, birds' nests and animal tracks or feathers.
7. One approach is to emphasize cycles, diversity of life and variety of textures. Repeat the field trip in all seasons. Notice the changes. Look for contrasting environments (such as open fields and dense woods, swamps and beaches, a road along a forest edge).
8. Another approach is to plan nature hikes around particular areas of interest. Examples are animal signs, wildflowers, non-flowering plants (lichens, mosses, ferns, horsetails and mushrooms), trees, insects and birds.
9. Introduce or review the concept of appreciation and care of the environment before all field trips. For example:
   - Do not pick wildflowers, break tree branches, crush toadstools and mushrooms, destroy spider webs or run through woodlots.
   - Take the time to step carefully. Look for new plants trying to grow in the soil.
   - Be quiet and courteous. Remember that you are a guest. All you should leave is a footprint.
10. The quadrat method is an effective way to study micro-environments. It works best if the quadrats are different in some way, for example, in a field, on a hillside and under trees. It is also best if each quadrat group is limited to about five participants.

    This is how to measure out a quadrat:
    - Measure out a length of 1 m on the ground. Mark both ends with a tent peg.
    - Measure another 1 m length at a 90° angle from one peg. Mark with a peg.
    - Repeat and mark with a peg.
    - When all four pegs are in position, mark the area boundary they create with string.

Activity 1: Nature Hike

Plan a nature hike suitable for the season and locale. These guidelines may be useful.

NATURE

1. Look for colors, light and shadows. How much light is coming through? Lie on your back and imagine that you are a sapling (young tree) trying to find sunlight. Is this a good place? Why?
2. Look for sizes, such as a tree and a seed or an insect and a bird.
3. Look for shapes. How many different shapes can you see in tree leaves and other plants?
4. Look for habitats. Is it sunny and dry or shaded and damp? What plants are growing there? Are the seedlings the same species as mature plants near by?
5. Use the sense of touch. Feel lichen growing on a tree. Compare it with the feeling of moss. Feel the bark on several different trees. Do they feel different? Why?
6. Use the sense of smell. Smell the leaves on the ground and the leaves on a plant above ground near by. Do they smell the same? Why?
7. Use the sense of hearing. Listen for bird calls, wind and rustling leaves. Which sound is the loudest?
8. Turn over a rock. What do you find beneath it? Look closely at the bark of a tree. What do you find there?
9. Use your imagination. If you were a small animal, like a rabbit or insect, where would you make your home? Why?
10. Share discoveries and observations.

Activity 2: Nature Trail

Have each participant create an imaginary nature trail using the theme of his/her choice. Examples are colors, textures, plants, sounds, etc. Each trail should be laid out along a piece of string about 2 m long and have points of interest every few centimetres. The points of interest should be visible under a magnifying glass and be keyed by number or color to a master list.

Have participants take turns guiding tours along the imaginary trails. They should describe the scenery, the neighbors, the atmosphere, the dangers, etc.

Activity 3: Camouflage

Scatter a number of different-colored toothpicks over a section of grass or field, and give participants a limited amount of time to find them. (If you wish, have them pretend to be birds looking for insects.)

Discuss the results. As a rule, the ones which blend into the ground will be the hardest to find. How do living organisms use camouflage to protect themselves?

Activity 4: Leaf Stamps

Collect leaves of different shapes and sizes. Explore textures and outlines with the help of colored pencils, crayons and an inked stamp pad.

Make some leaf stamps. Create silhouettes by putting a leaf on top of a stamp pad, placing paper over it and pressing firmly. Create leaf shadows by inking the leaf and then pressing it firmly against some paper.

Activity 5: Interdependence

All living things depend on other living things in order to live. What living things does a leaf need to grow? What living things need leaves in order to grow? Discuss.

Activity 6: Sun Action

Fasten leaves to construction paper (with pins or small stones) and place them in bright sunlight for an hour or longer. Remove the leaves to reveal the outlines left on the paper. Discuss how sunlight fades color.

Activity 7: Nature's Colors

Native Canadians and early settlers used natural materials to make dyes. Look for potential coloring agents during a nature hike. Bring back the materials, and try them on pieces of white paper.

NATURE

Activity 8: Shades of Color

Much of what is found on a nature hike, especially in bush or forest areas, seems to be green. There are many shades of green, however, and many other colors as well. Observe and record the variety and subtlety.

Activity 9: Change

During a nature hike, look for something that changes and something that never changes. Discuss the choices.

Activity 10: My Personal Tree

Play the "My Personal Tree" game to help develop senses other than sight.
(See page 79.)

Activity 11: Micro-Environment

Have participants form a line by holding onto a rope. Lead them through several micro-environments, pointing out different features along the way. Examples are moss-covered logs, cool forests, warm clearings, the crunch of dead leaves, smooth rocks and the smell of soil or decaying matter.

Activity 12: Curious Clues

Every natural outdoor setting offers curious, unexpected things. Examples are a mound of soil, a defoliated bush or animal tracks. These clues are evidence of interactions which have occurred (for example, a groundhog digging a burrow or insects eating leaves).

Look for curious clues during a nature hike. Discuss and speculate.

Activity 13: Natural Expressions

Introduce useful nature study terms and concepts appropriate for the age and interest level of participants. Examples are differences between fields and forests, the parts of trees and other plants and terms like succession.

Activity 14: Life in the Wild

What is life like for an ant in a grassy "jungle"? Describe it in words or pictures.

Activity 15: Animal Survival

What do animals (including human beings) need to survive? Discuss what happens to people if they are deprived of air, water, food and shelter. Discuss what happens to other animals.

Activity 16: Ratios

Measure the height of trees using ratios.

1. Select the tree to be measured.
2. Hold the measuring stick at a right angle to (perpendicular to) the ground.
3. Use a tape or pace measure to measure the length of the measuring stick's shadow.
4. Use a tape or pace measure to measure the length of the tree's shadow.
5. Use this formula to find the height of the tree.

$$\frac{\text{Length of measuring stick}}{\text{Length of measuring stick's shadow}} = \frac{\text{Height of tree}}{\text{Length of tree's shadow}}$$

Activity 17: Estimates

Measure the height of trees using estimates.

1. Place an object or a person of known height beside a tree.
2. Stand some distance away and estimate the number of "heights" of the object or person it would take to make up the tree.
3. Multiply as required.

Activity 18: Sound Count

Have participants sit quietly in a nature area with their eyes and fists closed. Tell them to lift a finger each time they hear a natural sound (such as bird, animal, weather and human sounds, but not including sounds made by the human voice). After a few minutes, compare and classify sounds heard.

Activity 19: Dandelion Focus

Conduct a study on one specific plant, such as a dandelion.

1. Mark off a 10 m^2 area with stakes and string. Subdivide into 10 plots of equal size.
2. Working in teams of two, count the number of dandelions found in the subplot. Extrapolate. If X number have been found in one subplot, how many are likely to be found in the whole staked area?
3. Collect results. Compare the totals for each subplot. Discuss why the counts may be different.
4. Count the number of seeds on at least 10 dandelions. Use that count to calculate average yields and estimate the total for the whole staked area. .

Activity 20: Quadrat Community

Use quadrats to study a variety of microenvironments. Suggest that participants look for the answers to questions such as these:

1. What kind of terrain is the quadrat in? Is it open and flat or steep and rolling?
2. Is it sunny and hot or shady and cool?
3. Is it windy or calm? From which direction is the wind blowing?
4. Are all the grass blades the same width and height? Is there more than one species of grass?
5. Are there different colors of vegetation?
6. Are there seeds present? How did they get there? From where did they come?
7. Are the plants low-growing or creeping? Are they bushy and tall?
8. Is there dead or decaying vegetation? Why is this important?
9. Are there any dandelions? Are they in flower or have they gone to seed?
10. Is there any clover with more than three leaflets?
11. Is there moss? Is it in a dry or moist place? What does it feel like?
12. Are there any wildflowers? Do they have a strong or weak scent? Why is this important?
13. Are there any thistles? Can you see their flower heads and spines? Why are these features important?
14. Are there any flying insects (such as bees, wasps or flies)?
15. What sounds do you hear?
16. Are there any aphids, grasshoppers or leafhoppers on the plants? Are they moving? How quickly?
17. Are the same insects in both short grass and long grass? .
18. Are there spiders, beetles, land snails, slugs, larvae or mites on the ground close to plant stems? How are these animals suited to the environment?
19. Is there evidence of other animal life? Examples are worm castings, worm holes, ant hills and spider webs.
20. What color is the soil? Is it wet, moist or dry?
21. How may soil particle size, texture and porosity affect animal life?
22. What is the temperature at ground level? At 1 m above ground level? Does temperature make a difference to survival of life in this quadrat?

Activity 21: Change

These explorations demonstrate that change is a constant in our environment, that it occurs at different rates and frequencies and that it may be natural or induced.

1. Discuss and develop examples of different types of change.
    - Diurnal are daily (flowers opening and closing).
    - Seasonal are regular but slow (snow, blossoms, fruit ripening).

- Successional are natural but even slower than seasonal (changes in an open field left undisturbed).
- Catastrophic and permanent are less frequent, but tend to be sudden and may be induced. Examples are floods, tornadoes, fires and clearing land for use as a building site.

2. Try Habitat Lap Sit (see page 72). Play it once with little direction. Repeat more slowly and with more direction. Discuss how the results demonstrate the effects on an ecosystem to sudden change (often, catastrophe) and to slow, natural change (often, successful adaptation).
3. Survey the school yard or a natural wood area near by for evidence of different levels of change.
4. Use the quadrat method to examine the land, air and water and types of changes occurring in each. Discuss and compare the results.
5. Play Hoppit (see page 71). This game illustrates how populations can adapt to natural changes, such as disease, but cannot survive for long when faced with a permanent change, such as loss of habitat.

Activity 22: Scales

These explorations demonstrate that land, air and water are vital components of the biosphere. Participants will likely find the Land, Air and Water Scale Guide helpful. (See page 40)

1. Discuss the concept of different scales. (The National Film Board's "Cosmic Zoom" is good for this purpose.)
2. Divide the group into pairs. Each pair should look at Earth through the small area formed by joining their fingers and thumbs. The idea is to examine relationships among land, air and water.
3. Divide the group in fours and fives. Have them join hands and look at a quadrat of one square metre for a medium view. Again, the idea is to examine relationships among land, air and water.
4. Have all participants join hands and take a caterpillar hike which ends by forming a large circle in some natural but perhaps disturbed area (such as a brushy area next to a ski slope).
5. Reassemble in the classroom to discuss the provincial scale. Discuss issues such as clear-cutting, drainage, hydro-electric dams, wetlands, soil erosion, recreational use of land and air pollution.

LAND, AIR AND WATER ACTIVITY

Scale Guide

Questions	Scale			
	Small	Medium	Large	Provincial
Describe the: Land				
Air				
Water				
Find one way each is being used. Land				
Air				
Water				
Which plants do you find?				
Which animals (or evidence of animals) do you find?				
Is there any evidence of human influence? List here.				

SOIL

Soil is an extremely important life support system. It provides both food and a home for millions of organisms. Yet the average person's knowledge of this natural resource tends to be limited.

OBJECTIVES

1. To develop an understanding of soil, including its composition, types, formation and properties.
2. To develop an appreciation of the importance of soil as a life support system.
3. To experience soil using the senses of smell, touch and sight.
4. To understand that soil resources need care in order to continue to grow food.

CONCEPTS

1. Soil is essential for life.
2. Soil is composed of four elements: rock, humus (such as conifer needles and deciduous leaves), air and water.
3. Soil type depends on the type of rock, the proportions of rock pieces and the type of humus.
4. Different soil types have different properties.

BACKGROUND INFORMATION

Soil Features

Soil has four main features: mineral particles, organic matter, pore space and water. Typical topsoil contains 45% minerals, 5% organics and 50% pore space.

Mineral Particles

Mineral particles come from rocks which have been weathered. Sand and silt break down by weathering, and essential plant nutrients become available. Because clay particles are very small, they have more surface area than the larger sand and silt particles. In most soils, clay particles provide most of the absorption surface for water and nutrients.

Organic Matter

Organic matter is composed of dead leaves, stems, roots and soil organisms. When decomposed, this matter provides essential nutrients for plants. It is also an important source of nitrogen.

Organic matter is like a sponge. It makes the soil crumbly. This helps make fields easy to cultivate and allows for quick water absorption.

Pore Space

Plant roots live in pore spaces. Oxygen (needed for root respiration) and water are stored here. Pore spaces also allow oxygen to diffuse into the soil and excess water to drain away. When soil is crushed or compacted by tractors or other heavy equipment, the pore spaces are lost. Both water and roots will have a harder time getting into the soil.

Water

The soil acts as a reservoir for the millions of litres of water which fall on Earth each second in the form of rainfall. Some of the rain runs off into lakes, streams and oceans, but about 75% enters the soil to be used by plants.

Too much water too quickly harms the soil just as too little does. Water running over bare soil will erode it. Too much standing water will form a pond, drowning the plants which were growing there. Water can also leach (wash away) essential plant nutrients, thus limiting plant growth. (Leached soils tend to be light in color.)

Soil Formation

Soil is formed by climate, relief, organic life, parent material and time. The type of soil that is made depends on how these five factors function.

Climate

Climate helps to weather rocks and contribute to soil formation. Weathering is the very slow process which breaks rocks, physically or chemically, into the fine particles needed to make soil. Rain, glacier, wind, sun, moving water and the cycle of freezing and thawing all help weather rocks.

SOIL

Chemical weathering produces mineral soil particles, which are a good source of plant nutrients. Rain produces chemical weathering because it is a very weak acid that can, over time, break apart rocks. Fresh rainwater is always slightly acid because of the carbon dioxide it picks up from the air.

Organic Life

Organic life means everything from microscopic bacteria to vegetation covering the soil and animals such as earthworms, gophers, spiders, beetles and snails.

Vegetation has a great effect on the characteristics of the soil formed. Forest, prairie and desert soils are all distinct.

Roots help form soil, too. They break apart rocks by finding small cracks and growing into them, prying the rocks farther apart. They also give off carbon dioxide as they grow, expelling the liquid in the form of carbonic acid. Although very weak, this acid-like rainwater "digests" the rocks over time.

Parent Material

Parent material is a major contributor. It may be a rock native to the area, or it may have been transported there. It may be sandstone, limestone, granite or any other rock. Some rock is harder than others and so more difficult to weather into soil. The minerals that make up the rocks also give the soil different characteristics.

Time

It may take as little as 100 a (years) or as long as 10 000 a (years) to produce two centimetres of good topsoil. This depends on the interaction of the other factors (climate, organic material and parent material). Under favorable conditions, it may take about 500 a (years) to produce three centimetres of good topsoil. However, it can be washed or blown away in just minutes.

In the past, large glaciers, hundreds of kilometres high and up to 2000 m thick, covered much of North America. As the ice moved, it ground the rocks under it, helping to form soil. Rocks frozen into the glaciers also acted as sharp tools that gouged and scratched other rocks as the glacier moved.

Over time, wind can chip away pieces of rock like a sandblaster.

Sun and the freezing/thawing cycle also help break rocks. Heat expands rocks, which then contract in the cold. Constant freezing and thawing is like being pulled in two directions. Eventually, water gets into the cracks and forces them to widen. (Water expands by 9% when frozen.)

As water moves, it picks up pebbles, particles of sand and other materials. A river carries large quantities of these articles. They swish along with the water, hit other rocks and knock off more particles. Sometimes, a river will flood, depositing these particles on its banks where they stay to become part of the soil.

Relief

Relief refers to the shape of the land. It may be flat plains, rolling hills, steep mountains or a combination.

The length and steepness of a slope have important effects on soil formation. On flat land, the soil may have a uniform thickness. On hills and valleys, soil thickness is likely to vary dramatically (thick in the valley, thin on the hill). This is because rainwater runs down hill, taking the soil with it to the valley floor.

Soil Profile

A cross section exposing the different layers of soil is called a soil profile. Each layer in the profile is called a horizon.

Soil profiles depend on the material from which it is developed, the climate, the vegetation covering the soil, the organic matter and the time of development.

Common profile horizons are:

1. Surface: Dark colored, many roots, much organic matter, high activity of organisms, commonly leached.
2. Subsurface: Moderately dark, many roots, moderate organic matter, commonly leached.
3. Subsoil: Below plowing depth, brown or reddish, more clay than on the surface, fewer roots.

4. Parent materials: Slightly weathered rocky mass from which the soil developed, very few roots, little plant or animal activity.
5. Bedrock: Rock from which the parent material developed.

Soil Structure

The structure of soil refers to the way in which the soil particles are grouped. Structure determines the movement of water as well as root and air penetration. It also affects how easily the soil may be plowed.

Typical soil structures are:

1. **Platy:** Thin, horizontal plants like pages in a book.
2. **Columnar**: Vertical columns with several smooth sides.
3. **Blocky**: Irregular blocks that fit snugly.
4. **Granular**: A collection of small spheres (the most desirable structures).

Soil pH

The pH factor measures the amount of hydrogen in soil. An acid soil, which has a lot of hydrogen, will have a low pH number on the scientific scale used to measure it. An alkaline soil, which has little hydrogen, will have a high pH number. The numbers range from 0 to 14. Moist soils have pHs between 5 and 8. (The neutral point is 7.) Most plants grow best in soils that are slightly acid (around 6).

Soil Color

Soil color indicates organic matter, drainage, biotic activity and fertility.

1. Red and yellow: Indicate the presence of iron. Are usually well drained.
2. Grey and blue: Indicate poor drainage and bog conditions.
3. Brown and black: Indicates fertile soil. (Color comes from humus.)

Soil Texture

Texture refers to the size of the particles that make up the soil. Particle size affects the movement of water in the soil as well as air and root penetration. Sand feels gritty, silt feels plastic when wet and clay feels sticky when wet and can be rolled into ribbons.

The best texture depends on the need. Potters, for example, use clay because it sticks together and can be shaped. Farmers prefer a soil that has neither too much sand (which drains too quickly) nor too much clay (which grips the water so tightly that plant roots cannot get at it).

Soil as a Source of Nutrients

Plants need a balanced diet made up of about 16 different nutrients. Each performs a special function.

Plants get carbon, hydrogen and oxygen from the air and from water stored in the pore spaces. Most plant food, however, comes from the soil itself.

These are the nutrients plants need in significant quantities for growth and health. Each nutrient has a special function to perform.

1. **Nitrogen**: Gives a healthy green color and helps plants produce good fruit.
2. **Phosphorous**: Gives energy to grow and to move food from one part of the plant to another.
3. **Potassium:** Gives vigor and vitality and helps make the root system healthy.
4. **Calcium:** Gives strength and stiffness to stay upright.
5. **Magnesium:** Essential for making chlorophyll, the food manufactured by plants.
6. **Sulphur:** Important for making up proteins and hormones.

In addition, plants need small amounts of other nutrients, including iron, manganese, boron, copper, zinc, molybdenum and chlorine.

SOIL

Soil Conservation

Oceans, seas and lakes cover 75% of Earth's surface. Of the remaining 25%, only 10% is high quality, reasonably level, fertile cropland. It is possible to feed the entire world's population with food raised on this 10%. Much of it, however, is being allowed to erode or is being used for other purposes.

Soil Erosion

There are are several types of soil erosion. These include splash, sheet, rill and wind erosion.

Splash erosion is caused by water. Falling rain causes a geyser-like splash and makes miniature craters in the soil. Soil particles are thrown into the air and then dropped into new positions. The effect is to make the soil surface less able to absorb water because the natural soil openings become clogged with the flying particles. Soil on sloping surfaces will be shifted slowly down hill.

Sheet erosion is caused by water as well. It tends to be less noticeable because it happens gradually on flat lands. It occurs when the overland flow of water removes a uniformly thin layer of topsoil. Very small amounts are removed at any given time.

Rill erosion occurs where slopes are steep and water run-off is heavy. The water bites down into the soil, creating rills, which are small gouges and channels. Gullies are created when several rills form larger channels. This type of erosion is difficult to stop because the gullies tend to develop progressively upslope, biting deeper and deeper into the hill.

Wind erosion tends to occur on flat lands where there are no barriers to break its speed or power and where topsoil is exposed.

The eroded soil itself causes problems. It must be deposited somewhere. Often, it covers fertile soils and plants or gets into ditches, streams, reservoirs and rivers.

Preventing Soil Erosion

Loss of any cropland is a matter of concern. Loss of flat croplands is of particular concern. However, various techniques have been developed to help cultivate hilly lands.

One technique is contour plowing. This means plowing according to the shape of the land (around the hills) rather than straight up and down. The result is to create furrows which act as little dams, thus preventing water from washing soil down the hill slope.

If the slope is extreme, terracing can be effective. This means cutting steps up the slope and planting crops on the flat. Grass channels are used to direct water into ditches and prevent loss of soil.

Alternating crops is another technique. Called strip cropping, this involves alternating grain or other crops that give little soil protection with strips of closely grown crops or sod that do.

Shelterbelts and windbreaks can help break the speed of wind, a major soil eroder in some areas.

Conservation tillage is another technique with good results. This means keeping the ground covered with the crop's residue, such as stems and stocks, rather than plowing it under. Some farmers also add mulch.

Crop rotation can also be helpful. This helps build up worn out soil as well as preventing loss by erosion.

SOIL ACTIVITIES

Before You Start

1. The ideal site is one which offers a variety of environments, such as an open field, conifer trees, deciduous trees and a body of water. It should also be within convenient reach so that travel time and costs are limited.
2. Dress for the weather and the site. Participants should wear clothes that are suitable for hands-on, outdoor activities. In most cases, outdoor clothing and running shoes are appropriate.
3. Collect and prepare the equipment you will need in advance. Typical soil study activities require this equipment:

SOIL

- Trowels and spoons.
- Newspapers.
- Measuring cups.
- Glass jars with lids.
- Several cans with holes punched in the bottom.
- Wire mesh (1 cm) baskets.
- Water.
- Clipboards, paper and pencils.
- A glass terrarium. (See below for instructions.)
- A soil probe.
- Wooden boxes.
- Watering cans with sprinklers.

4. Introduce or review the concept of appreciation and care of the environment before all field trips. For example:
    - Collect with care. Do not change the environment any more than absolutely necessary.
    - Do not pick flowers, grasses or other plants.
    - Do your best to return the environment to the state in which you found it.

Things to Make

1. This is how to make a soil terrarium.
    - Get five pieces of window glass. Two should be 25 cm x 20 cm (for the ends), two should be 25 cm x 40 cm (for the sides) and one should be 43 cm x 22 cm (for the top).
    - Tape the glass ends and sides to make a rectangle.
    - Get a shallow pan about 43 cm x 22 cm x 2 cm.
    - Spread freshly mixed plaster of paris over the bottom of the pan.
    - Press the glass rectangle firmly into the plaster of paris. Let stand to harden.
    - Put the glass top in place.

Activity 1: Soil Basics

Become familiar with soil terms and concepts. Have a spelling lesson, a spelling bee or other games using soil words, such as clay, gravel, gritty, loam, mineral, organic, sand, silt, soil grains, erosion, fossil and pebble. For example, participants could make up and trade crosswords, mix and match, fill in the blank, multiple choice or nonsense definition games.

Activity 2: Soil Samples

Explore the composition and formation of soil with hands-on sampling. Divide participants into soil sampling teams. Each team should obtain a sample from a different site with different features (such as an open field, a conifer forest, a deciduous forest, a road, a garden or a site near a body of water). Examine and discuss various aspects.

1. Consider colors. How different are they? Why?
2. Consider grain sizes. Rub the soil between the fingers or palms to make sure that clumps are broken. (This is to prevent confusing clumps with particles or grains.) Rate the soils on a scale of from 1 (for very coarse, such as gravel) to 5 (for a fine powder, such as clay, that would get into the pores of the skin).
3. Consider composition. Of what are soils made? Are any of these ingredients visible in the samples? What causes rocks to break down into soil? Did any rocks show signs of weathering? Are there any particles in the samples? Were the particles always this size? What may have changed them?
4. Consider appearance. What do the samples look like? How do they feel? What happens when a handful is squeezed? Compare the results. What may cause these differences?

SOIL

5. Consider smell. Do the samples have an odor? What does each smell like? What causes soil odors?

6. Consider water capacity. Put a sample (to a depth of 4 cm) from each site in a separate can with holes punched in the bottom. Pour 100 mL of water into each can. Measure the volume of water which has run through each can after a specific period of time.

Activity 3: Soil Differences

Why do soils differ? Consider the relative concentration of rocks and minerals to humus. Discuss the characteristics of color, grain size, texture and rate of water percolation. Note that smell, color and rate of water percolation are determined by the source of humus.

Activity 4: Soil Erosion

What causes rocks to break into such tiny pieces? Discuss erosional forces, including glaciers, streams, rain, wind, root action, acids secreted by plant roots and temperature changes.

Activity 5: Humus

Discuss the role of humus. Experiment with forest litter to see how different dead plant material (such as conifer and deciduous leaves) may create different soils.

Take two fistfuls of soil, one rich in humus and one poor in humus. Place each sample in a wire mesh basket and lower gently into a glass jar about two-thirds full of water. Compare results. Note how the rich soil tends to hold together while the poor soil tends to fall apart and drop to the bottom.

Activity 6: Soil Game

Develop a visual image and concrete understanding of soil composition and plant growth with this game.

1. Divide the group in two. One team should have five to eight members. The other, larger team should be made up of the rest of the participants.
2. Divide the smaller team into two parts. One or two members will take the role of animals that live in the soil. (Note that this includes bacteria and molds.) The rest will take the role of plant parts.
3. Divide the larger team into thirds. One-third should take the role of clay particles, one-third should take the role of sand particles and one-third should take the role of silt particles.
4. Tell the clay, sand and silt particles to mix up and stand in a disorganized clump at arm's length from one another. This is to simulate the way soil particles are mixed up. The spaces between them are where air, water, plant roots, decomposing organic material and animals exist.
5. Create a plant root by arranging the plant parts in a straight line. Have them hold hands and move apart until their arms are fully extended. The leader, who represents the growing end of the root, then weaves a way through the spaces in the soil clump until reaching the other side. The root line then stops.
6. Establish an understanding of how plant roots anchor the plant growing above and take minerals and plant food from the soil particles, water and air. Discuss such questions as these: What does the plant need to grow? Where does it get this? In what other ways is the soil important to the plant?
7. Now, have the individual animals move about through the open spaces as they look for the food, shelter and water they need.
8. Establish an understanding of different soil types. Ask the plant root and animals to show how they would move if all the soil particles were made of sand. Repeat with clay. Discuss such questions as these: What difference is there between sand and clay? Could animals and plants

survive easily in soil made of just sand or just clay? Why? .

9. Repeat this activity, introducing rain. Discuss such questions as these: What happens when rain falls on the soil? (Some is absorbed, some is evaporated and some runs off.) What can happen to soil when rain runs off?
10. Repeat this activity, introducing a dramatic, permanent, external factor, such as a covering in the form of a building or road. What happens to the pore spaces? (Demonstrate by having soil particles move closer together.) What happens to plant roots and animals? (They may disappear altogether.)
11. Repeat this activity, introducing a less dramatic, changing, external factor, such as a planting of grass or other vegetation. What happens then? (Over time, pore spaces become larger, more water and air move in and more roots grow.)

Activity 7: Wake Up Garden

Develop an understanding of the life processes occurring within soil. In spring, shortly after the winter thaw, dig up a rectangle of topsoil about 10 cm x 10 cm x 2 cm. Put the soil in a terrarium and set it in good light.

As the soil warms up, many small creatures will begin to move about. You are also likely to see many small plants sprouting from seeds that have been buried in the soil.

After several weeks, empty the garden on to large sheets of newspaper. Count the number of plants and animals that were living in the soil.

Activity 8: Orchard

Use the terrarium to raise a miniature orchard. Wash the container thoroughly and cover the bottom with clean gravel or bits of broken flower pots (to provide good drainage). Spread about 7 cm of well-sifted, sandy garden soil with some leaf mold added. Plant orange, grapefruit, lemon, apple or acorn seeds.

Activity 9: Rock Formations

Collect rock samples. Mount in plaster casts and label. Use a rock and mineral identification guide to help. If you wish, break apart some samples with a hammer to look more closely at the components (a magnifying glass will be helpful). Discuss how the proportion of rock pieces of various sizes may cause soils to differ.

Activity 10: Animal Count

Count and compare the number of animals found in a rich soil sample and a poor soil sample of the same size. Discuss the importance of these organisms to soil.

Activity 11: Splash Erosion

Look for splash erosion after a rain on sidewalks, fences and other places. Note that trees and grasses slow down the speed of raindrops and protect the soil so that direct hits are avoided.

Demonstrate the effectiveness of soil coverings with this experiment. Pour water from shoulder level on to a pile of bare soil and on to a pile covered with plants or some other kind of covering.

Activity 12: Decomposers

Discuss the importance of decomposers such as fungi and earthworms in the formation of soil.

Activity 13: Roots

Discuss the role of roots in breaking down parent material and in soil formation. Look for cracks in sidewalks and tilted sidewalks near large trees.

Activity 14: Soft and Hard

Compare samples of soft rocks (such as limestone or sandstone) and hard rocks (such as granite). Rub together to obtain one gram's worth of particles. How long does it

SOIL

take with the soft rock? With the hard rock? What does this say about the time needed to form soil from rocks?

Activity 15: Weathering

Compare samples of rocks found near rivers or beaches and elsewhere. Which are smoother? Why? What likely happened to the weathered particles?

Activity 16: Glaciers

Fill a flat box with soil and small rocks. Freeze a block of ice in a milk carton, remove the wrapping and place the block on the soil at one end of the box. Tilt up the box slightly at that end, and watch the block of ice slide slowly down the soil. Look at the grooves in the bottom of the ice block. Compare them with the grooves in the soil. Discuss the action of glaciers.

Activity 17: Temperature Changes

Hold a small piece of limestone in tongs over an open flame or hot plate. After heating, drop the limestone quickly into a pan of ice water. What happens to the rock? (It should break or crack.)

Activity 18: Cold

Fill a glass jar with water and set it outdoors to freeze. Or wrap the jar in a plastic bag and place it in an indoor freezer. What happens to water when it freezes? (The jar should break or crack.)

Activity 19: Water Penetration

Put equal amounts of soil into two large, round clear glass jars. One soil should be high in organic matter and one should be low. Add equal amounts of water, and observe the water penetration levels. Soil high in organic matter holds water better, allowing plant roots to get at the water more easily. Soil low in organic matter runs off or drains quickly. Plant roots cannot get enough water, if any.

Activity 20: Soil Settling

Fill a clean, clear glass jar about two-thirds full of water. Add soil that is a good mixture of sand, silt and clay until the jar is almost full. Close well and shake thoroughly. Let stand for several hours (about two is the minimum). Check periodically. How long does it take for the soil to settle and the water to clear?

Activity 21: Soil pH

Collect moist samples of as many different soils from as many different locations as possible (examples are forest, pasture, heavily cultivated, bog, garden). Use pH paper to test each sample. Match the color to the value listed on the paper. Which soil has the best pH for plant growth? (About 6.0 is ideal.)

Activity 22: Soil Life

Collect a soil sample from a forest and a cultivated area. Take a quick count of the organisms found in each (including bugs, earthworms, roots, spiders and anything else visible). Compare results. Why are there more organisms in the forest sample than the cultivated sample? (The forest may be more diverse, more forms of life may have a chance to develop, there may be more dead plant and animal materials for organisms to feed on and cultivation may disrupt soil organisms.)

Activity 23: Soil Profile

Examine soil profiles in different areas, such as a woodlot, a pasture and a field.

If a soil probe is available, use it to take a core, or sample, of soil from the ground. Remove the core and put it in a container for study.

If a soil probe is not available, find an exposed road cut where soil layers are visible or dig a pit to expose them.

Analyse the soil. Diagram and label the

profile, including topsoil, subsoil and parent material. Show the depth of each layer as close to scale as possible.

Determine texture by feel and observation. (Is the soil made up of sand, silt or clay?)

Determine the structure by observation. (Is it plate-like, blocky, granular or other?) Determine the pH level.

Activity 24: Soil Conditions

Observe and take samples of soil from different locations in the school yard. Find an area with heavy grass cover. (Is the soil soft or hard?) Find an area that has been heavily trampled or eroded. (Is the soil soft or hard?) Put soil samples in bags and label them.

Activity 25: Water Erosion

Demonstrate the effects of water erosion with this experiment. Fill two wooden boxes (about 40 cm x 30 cm x 10 cm) with soil taken from the same location. One sample should be bare soil and one should be sod.

Place fruit jars with spouts to catch run off at one corner. Tilt the boxes slightly. Use water cans to pour the same amount of water from the same height (about 30 cm) on the boxes at the same time.

Observe the water draining into the jars. The water from the sod sample will flow in a smaller quantity and more slowly. It will also be fairly clear. The water flowing from the bare soil sample will flow more quickly and be fairly muddy.

Repeat the experiment holding the boxes at different levels to demonstrate the effects of water erosion on steep slopes and flat lands.

Activity 26: Wind Erosion

Use an electric fan, two pieces of soft, white cloth, a 30 cm x 40 cm box and miniature trees and shrubs (cardboard or posterboard cutouts) to demonstrate the effects of wind erosion.

Fill the box with dry, powdered soil. Hang a moist, wet cloth behind the box. Create a dust storm without the trees. Record the amount of time the wind blows. Turn off the fan and examine the amount of soil blown onto the cloth.

Repeat with a clean backdrop and trees and shrubs. Set the cutouts in a row, closely together enough to overlap branches. Staple the trunks to a small piece of board. Set the board in position. Face the trees flat side to the wind, and bury the board in the soil. Turn the fan on for the same amount of time, and examine the results.

If you wish, repeat with variations. For example, set the trees in shrubs in multiple rows, place the trees farther apart, use carrot or other plant tops to simulate a real windbreak or put a sod cover on the soil.

Activity 27: Soil Collage

What comes from the soil, directly and indirectly? After a discussion, use clippings from newspapers and magazines to create a collage with an individual theme (such as erosion, farming techniques, plants, food, etc.)

Activity 28: Soil Nutrients

Discover the importance of soil nutrients with this experiment. Fill four containers with equal measures of topsoil and fertilizer; topsoil only; eroded soil; and subsoil. Plant several beans in each pot, place them in the sun and water regularly. Observe the results. Which soil produces the healthiest plant growth?

If possible, repeat with different seeds. Also, if possible, establish a compost heap with domestic wastes. Use the compost with various types of soil.

WASTE

Waste disposal and management is a major environmental issue. We are producing far more waste than can be dealt with by natural processes. Each person in Ontario, for example, produces about two kilograms of garbage every day. This adds up to a total of some seven million tonnes annually. Hauled liquid waste adds another 270 million litres, of which about 10% is toxic or hazardous. As the problem grows, the need for solutions become more urgent. Public awareness and involvement in the management of waste is critical.

OBJECTIVES

1. To foster awareness of litter and waste.
2. To learn about some methods of waste disposal and their effect on the environment.
3. To develop an understanding and appreciation of the need for waste management.

CONCEPTS

1. The volume of waste is growing faster than the number of places to put it.
2. The volume of waste going to landfill sites can be reduced by re-using, recycling, and recovering from the waste stream.

BACKGROUND INFORMATION

Composition of Waste

Waste, or garbage, is anything we discard because we do not want or need it.

Typical household waste is made up of paper (25%), food (22%), yard waste (15%), newspapers (10%), glass (8%), cans (7%), other metals (1%), and other substances (12%), which often include plastic containers and wrappers.

Municipal waste (usually made up of household, commercial and industrial waste) is the responsibility of municipal governments. Although this often includes hazardous waste materials, such as paint cleaners, most municipal waste consists of household garbage.

ontrolled waste (sometimes called industrial waste) consists of special or hazardous materials which require greater care in handling and disposal. It includes some chemicals and other materials which may pose a danger to human health or safety because it is poisonous, radioactive, explosive, corrosive or disease-causing.

Waste Disposal

Dumping

For many years, dumping was the waste disposal method of choice. Garbage was hauled to open dumps on selected pieces of land and left to decompose in the open air. In some cases, the waste was burned.

There are several problems with dumps. One is the foul odors they generate. Another is their attraction to disease-carrying or otherwise undesirable animals (such as rats, mice, bears, and skunks). They also tend to leach contaminants into the ground water supply. Burning the waste pollutes the air with smoke.

Because of these problems, open dumps are being phased out by Environment Ontario.

Incineration

Some municipalities use incineration as one waste disposal method. However, incineration does not get rid of the waste; it only changes its nature. Incinerators burn waste at very high temperatures. This reduces it to gases, such as carbon dioxide, and ash residue. The gases are then cleaned of most of their pollution and released into the open air. The ash residue is usually buried in a nearby landfill site.

Incineration is better than dumping because the burning–and air pollution–is controlled. Also, the volume of waste is significantly reduced.

However, there are several disadvantages. The process is expensive because incinerators must be built and maintained. It is labor intensive (workers must be hired and trained). Significant energy is needed to burn the waste. An ash residue remains. Also, incineration destroys some important recyclable materials, such as paper.

WASTE

Landfill

Landfilling is currently the waste disposal method most commonly used in Ontario. A sanitary landfill site is selected; waste is dumped, crushed and covered with a 15 cm layer of earth. When the site is full, it is covered with a final layer of 60 cm of earth.

Regulations ban open burning of waste and control of dust and litter. They also require fencing to prevent illegal dumping. Other measures ensure control of insects and small animals.

Landfilling offers several advantages. An important one relates to cost. Land may be purchased or leased, and no building or incinerator is required. The equipment needed may be of the type standard in the construction industry (although special equipment is sometimes required). Workers do not need special training. Animals and insects can be controlled. The end product is a properly isolated site with proper monitoring. The site can be put to recreational use, for example, as parks or ski hills.

There are problems as well. Among the most serious is the lack of suitable sites within economic reach of the municipalities which most need them. Suitable sites are also likely to be adequate for farming or housing. Such uses are impossible, however, once the land has been used for landfill.

Another problem relates to the fact that a vast quantity of non-renewable resources is being buried rather than reclaimed. Oil-based wastes, like plastics, synthetics and packaging, or metal-based products, such as cars or aluminum foil, could be re-used and recycled.

As it decomposes, the waste in landfill sites produces methane gas. In some cases, the methane is explosive.

Landfill sites retain some of the characteristics of dumps. These include unpleasant odors, the possibility of ground water pollution and the presence of unwanted pests.

On balance, landfilling should be considered as an interim measure until improved waste management practices can be developed.

Waste Management

Waste management means planning for control of waste both before and after it is created. Sound management measures cut down on the amount of waste in the first place. This involves the four R's: reduction, re-use, recycle and recovery.

Reduction

Waste reduction means cutting down on waste-creating materials, such as packaging, disposable items and non-durable products. Examples are found in every household: plastic bags, styrofoam cups and trays, non-returnable soft drink bottles and cans, disposable diapers, paper plates, napkins and paper towels and disposable batteries and pens. Other examples include toys, tools and equipment which cannot be repaired when a piece is lost or broken.

People can have an enormous impact in this area. By buying rechargeable batteries and soft drinks in returnable bottles or by avoiding products with unnecessary wrapping, they can reduce household waste significantly.

Re-use

Waste re-use means finding another use for products which would otherwise be thrown away. Refillable soft drink bottles are a good example. Another is plastic cartons and tubs, glass jars and plastic bags. Once washed, they can be used to store leftover food and other household items.

Re-use depends, of course, on the durability of the materials. Some can be re-used many times. Others, like paper, may not stand up for long.

Recycle

Recycling waste means breaking it down to its basic parts and then using some or all of them for another purpose. Some materials can be recycled fairly easily (paper, glass, metal and certain chemicals). Others are difficult to recycle (plastics and rubber).

The ways in which a material can be recycled will depend on its versatility. Paper, for example, can be recycled to make more paper, or it can be turned into insulation material or fuel. Glass can be recycled into new glass containers or ground up for use as cullet with asphalt for paving roads.

The first step in recycling is to separate at source. This means sorting useful waste from non-useful waste before setting it out for collection. As a rule, this means separating paper, metal and glass from the rest of the garbage. (In many Ontario towns and cities, residents are given special boxes for separated garbage.)

Recovery

Recovery, often called resource recovery, means processing waste to remove useful materials or energy. As much as 90% of the waste can be converted into useful products, such as refuse-derived fuel or compost (fertilizer). Some parts can also be recycled. Industrial wastes may be processed to remove certain chemicals or to mix wastes with other products in order to produce new materials.

The recovery process requires high technology. Mechanical separators are used to remove some items, such as ferrous and non-ferrous metals, glass and plastics. The remaining waste is decomposed into compost or taken to landfill sites.

Energy can also be produced by burning unprocessed or partially processed waste. This produces hot air, hot water or high or low pressure steam, all of which may be used to heat buildings or produce electricity.

Barriers to the Four R's

The four R's seem to offer the best alternatives to current waste disposal methods. Yet, they have not yet significantly changed our habits or reduced the amount of waste we are producing. Why?

One reason is lack of information. Many people are not aware of the four R's or related programs in their area. The public may not be aware of the high economic and social costs associated with waste disposal and management. As a result, it seems cheaper to continue to burn or bury waste than to apply the four R's. Social attitudes also play a part. In North America, we have become accustomed to a throwaway life built on convenient, disposable products and packaging.

There is also a lack of industrial or commercial buyers of recycled or recovered materials. Until markets are built up, these two R's will not be economic.

Furthermore, municipalities lack the financial resources to acquire the equipment and technology required to set up needed recycling and recovery programs.

The Role of the Individual

People can help create responsible waste management systems by:

1. Composting food wastes. This reduces the amount of organic waste needing disposal and frees nutrients which would otherwise be trapped in a landfill site.
2. Altering food-buying habits. By buying re-usable, refillable and repairable items, people can both reduce the amount of waste and create a market for recycled materials.
3. Re-using containers and other waste products. This will reduce the amount of waste.
4. Supporting recycling and resource recovery projects.
5. Participating in citizen groups and waste management advisory boards.
6. Participating in source separation (recycling) programs.

The Role of Industry

Industry can help create responsible waste management systems by:

1. Identifying products which contain recycled materials. This may encourage consumers to buy recycled products and participate in recycling programs.
2. Altering packaging. Using the minimum amount needed for the purpose, standar-

dizing containers, reducing the number of container sizes and reducing the use of laminates, non-soluble glues and bi-metallic cans.

3. Using recycled material. This will help reduce the cost of non-renewable resources, which will become more expensive as they become more scarce.
4. Building more durable and repairable products. Products with a longer life will significantly reduce the amount of waste.
5. Taking advantage of energy from waste programs. By providing a market for such energy, industry can make these plants economical for everyone.

The Role of the Municipal Government

Municipal governments can help create responsible waste management systems by:

1. Developing source separation and recycling programs, which can reduce waste by up to 20%. In the short term, this may be more expensive than current methods. However, savings can be achieved through lower costs for such items as additional landfill sites, perpetual care, land replacement and environmental damage.
2. Keeping citizens informed. People are more likely to participate if they are informed.
3. Setting up resource recovery plants. Done alone or jointly with other municipalities, these plants can divert up to 90% of municipal waste from landfill sites. This extends the life of the site, reduces the demand for land and spares other resources.
4. Developing waste management plans, preferably with the help of industry and the support of the public.
5. Encouraging and supporting industrial recycling and recovery projects. This will both reduce industrial waste and provide markets for municipally recycled and recovered materials.
6. Collecting data on waste. In order to plan and manage waste properly, municipalities need to know how much waste is produced, in what form and how it is being handled. This information is essential for predicting what facilities and money will be needed in the future.

The Role of the Provincial Government

The provincial government, and in particular Environment Ontario, must continue to play a strong leadership role in waste management. These are some of the initiatives the government is establishing:

1. Informing the public. This is the key to the success of the four R's. It ensures that individuals, industry and municipal government alike realize the inherent benefits. It encourages them to take part, emphasizes their separate roles and provides incentives for communication and co-operation among the public, municipal and industrial sectors.
2. Assisting with set-up of source separation and resource recovery projects. By providing initial financing or technical help, many effective projects can be established and maintained.
3. Demonstrating new technology and waste management practices. Projects such as the Experimental Resources Recovery plant, established by Environment Ontario, introduce new concepts and practices and prove their viability.
4. Finding and developing markets for recycled materials. This encourages recycling and resource recovery.
5. Co-operating with industry in providing a "good packaging" symbol. A symbol that identifies goods made of recycled materials will encourage public support.
6. Increasing government use of recycled materials. This provides both a good example and a large and stable market.

WASTE

WASTE ACTIVITIES

Activity 1: Garbage Parade

What is garbage? Develop a definition by considering examples of discarded materials from the average household. Discuss questions such as what the item is, for what it was used, and what will happen to it next. Ask participants to name items disposed of as a matter of course in their homes.

Activity 2: Beautification

What would your home look like if it were the most beautiful place in the world? Describe it in pictures or words.

Activity 3: Litter Hurts

Litter affects more than the aesthetics of the environment. Demonstrate with a short skit. Assign participants roles such as rabbit, flower, worm, bird and fish, all of which live together in happy harmony. Then introduce a litterbug who carelessly deposits a plastic cup, an empty gas can, a newspaper and a still-smouldering match. The rabbit cuts its foot on the cup. The fish dies from water pollution caused by gas residues. The flower smothers under the newspaper. The fire started by the match destroys the forest and drives all the other organisms away.

Activity 4: Litter World

Demonstrate the cumulative effect of waste in a crowded world. Have participants stand around a circle, which is defined as the world. Each should hold a piece of paper, representing personal litter, above the head. They then enter the world in pairs. When everyone has entered the circle, have them drop their litter and step out of the circle. This provides a visual image of the impact of litter on the environment.

If you wish, follow up by having one participant stack all the litter in neat piles within the circle. This demonstrates that garbage may be tidied up but still exists.

Activity 5: Litter Collection

Demonstrate litter collection and disposal by starting with a collection. Discuss where litter commonly collects and how to control littering. Divide participants into teams, designate team leaders and assign a collection territory to each team. Give each team leader a large garbage bag.

When the teams return, empty the bags into the school garbage containers, save the bags for re-use, and discuss the next steps in the waste disposal process.

If possible, follow up with a visit to a sanitary landfill site.

Activity 6: Renewable Resources

What is the difference between renewable and non-renewable resources? Develop examples of each.

Activity 7: Waste Disposal

Discuss the three main methods of garbage disposal (dump, landfill, incinerator). Chart the main points (how the method works, its effects, what happens to the land, what happens to the resources in the waste).

Activity 8: Landfill Close Up

Simulate a landfill site by alternating layers of soil with layers of garbage in a large clear glass jar. Place the waste items (such as aluminum foil, candy wrappers, apple cores and plastic wrap) at the side so that they are visible. What are the problems with landfill?

Activity 9: Incinerator Close Up

Demonstrate incineration by placing waste items on an aluminum pie plate. (Make sure the room is well ventilated and a fire extinguisher is at hand.) As the objects burn, observe the odors and ash residue which are created. What are the problems with incineration?

Activity 10: Garbage Relay

After collecting litter in selected areas, have teams compete in a garbage relay. Players take turns running to a garbage can, depositing a piece of litter, and running back to tag the next player on his/her team. The winning team is the one which gets rid of its garbage first.

Activity 11: Garbage Round

Sing this recycling song to the tune of of "Frère Jacques". Sing each line twice and in rounds.

Save your tin cans,
Bottles, too,
Put them in a blue box,
Good for you!

Save your papers,
Mag-a-zines, too.
Tie them in a bundle,
Good for you!

At the market,
Save your bag,
Use it once or twice more,
Good for you!

Activity 12: The Four R's

Discuss the role of the individual in eliminating waste by paying attention to the four R's (reduce, re-use, recycle and recovery). Develop lists of practical steps people can take every day. Examples are using both sides of a page of paper, cutting up old clothes for rags, refusing unnecessary bags in stores, using a lunchbox rather than a lunch bag and buying soft drinks in refillable containers.

Activity 13: Litterbugging

What effect does a litterbug have on the environment? Imagine a community infested with litterbugs. Describe it in pictures or words. What would it look like if cleaned up?

Activity 14: Litter Source

What is the difference between natural litter and litter made by people? Is natural litter good? Does litter made by people decompose? How does litter made by people hurt plants, animals and people?

Activity 15: Composting

Discuss composting. What is it, and where does it fit in the waste management spectrum? If space and time permit, develop a compost heap in the schoolyard.

Activity 16: Recycle and Re-use Sale

Demonstrate the kernel of truth in the old saying that one person's garbage is another person's treasure. Ask participants to donate items which they no longer want for a recycle and re-use sale. (Remind them that the items should be clean and in good repair.)

Before accepting any item, ask the donor to re-assess it. Why is he/she giving it away? Can it be re-used? Recycled? Recovered?

Advertise the sale, and donate the proceeds to a local charity.

Activity 17: Litter Awareness

Develop litter consciousness with a variety of spot activities, all directed at awareness of litter.

1. Make litter maps of the community. Where is litter found? What type is it?
2. Make and decorate litter bags to put in motor vehicles. Have participants take

them home or give them away as part of a community litter awareness day.

3. Decorate the school's garbage cans. Make them visually attractive and attention-getting.
4. Collect and bundle newspapers for recycling.
5. Have a scavenger hunt. Participants should hunt in pairs for litter, such as bottle caps, soft drink cans and candy wrappers. Award prizes for the most items found, the most unusual item found, etc.
6. Use litter found during the scavenger hunt to make and decorate litter figures, such as "Litter Bird," "Lousy Litterbug" and "Litter Loser."
7. Graph litter profiles. Categorize the litter found during the scavenger hunt, and draw charts or graphs to show which types were found in which areas.

Activity 18: Litter Evidence

Visit an undeveloped area to look for evidence (direct and indirect) that people have been there before. Encourage originality. Look for examples other than litter.

Activity 19: Landfill Roleplay

Develop a roleplay focusing on issues surrounding landfill sites. Stage a town meeting in which the need for and selection of a new site is under discussion, Roles could include the town mayor, owner of the potential site, manager of a factory which produces considerable waste, residents living near the proposed landfill site, residents living near the factory, environmental experts, etc.

Activity 20: Non-returnable Roleplay

Develop a roleplay focusing on issues surrounding non-returnable containers. Stage a town meeting in which a proposed ban on non-returnable containers will be discussed.

Witnesses should include:

1. A steel manufacturer, who will testify that this law will cost the town money and jobs because sales will drop.
2. A consumer, who will testify that beverages in returnable containers are less expensive.
3. A large bottler, who sells to wholesalers, will testify that manufacturers and retailers prefer non-returnable containers because they are less of a nuisance to handle.
4. A small bottler, who sells directly to consumers, will testify that consumers prefer non-returnable containers.
5. A beverage distributor, who will testify that the ban will raise prices because his/her warehouse will have to be enlarged to store the empties. .
6. An ecologist, who will testify that non-returnable containers waste energy and other resources. Returnable bottles can be used 20 to 50 times. If only returnables were used, many fewer would be needed.
7. An unskilled worker, who will testify that returnable bottles will eliminate some jobs in steel and bottle-making factories, but that more jobs in bottling plants, transportation and beverage distribution will be created.

Activity 21: Earth Source

Trace components in order to demonstrate that Earth is the source of most products. Have participants name items made from paper, metal, glass or food. Identify the elements and their source. Examples are: cereal box (paper, wood, trees, soil, earth); soft drink can (minerals, rock, earth); jam jar (glass, sand, rocks, earth); apple (trees, soil, earth).

WATER QUALITY

Like all nations, Canada is concerned about its water resources. Great efforts are being made to protect and improve water quality and supply.

OBJECTIVES

1. To develop an understanding and appreciation of the role of water in both human and non-human environments.
2. To increase awareness of water pollution sources.
3. To increase knowledge about activities and programs designed to improve water quality.
4. To increase awareness of what people can do to solve water-related problems.

CONCEPTS

1. Polluted water is water of lower quality than desired for the intended use.
2. Water pollution may affect the entire watershed and ecosystem.
3. Water quality may be improved by treatment methods, sound land use and conservation practices and a caring public.

BACKGROUND INFORMATION

Sources of Pollution

"To pollute" is usually defined as "to make something foul or filthy." Pollution, however, means different things to different people and in different contexts.

For example, distilled water is usually considered the purest form of water. But since it lacks nutrients and minerals necessary for the growth of micro-organisms, invertebrates and other creatures that serve as food, fish could not survive in distilled water. Thus, a lake of distilled water could be referred to as "polluted."

Seawater, on the other hand, contains large quantities of dissolved salts, which make it unsuitable for drinking, irrigation and many industrial uses. Yet many marine organisms and fish flourish in it. Whether seawater is "polluted" clearly depends on one's point of view.

Pollution is usually associated with human endeavors and activities. However, many sources of pollution occur naturally. One example is leaves falling from trees which overhang bodies of water (organic pollution). Another is a high bacteria count resulting from the natural decay of bacterial organisms flourishing in aquatic reeds. (This is sometimes confused with pollution from sewage containing disease-carrying bacteria and viruses.)

Water pollution can be divided into two categories: surface water (lakes, rivers, and streams) and ground water (underground water reservoirs called aquifers).

About 40% of Ontario's population gets its drinking water from ground water wells of one sort or another. For this reason, solid waste disposal through sanitary landfill is being watched very closely, as are other potential sources of ground water contamination. Organic matter (in discarded waste decays or ferments) and persistent materials (such as salts) also percolate down to the aquifers.

Improving Water Quality

Nature has a natural capacity to cleanse water through natural interaction of sunlight, dissolved oxygen extracted from the atmosphere and micro-organisms. Left to itself, nature can cleanse water polluted by natural processes and by some human sources. However, the process tends to be slow, particularly with ground water.

Human sources of pollution have overloaded nature's capacity in many areas and have introduced pollutants which nature cannot handle. This creates unsightly or unpleasant situations, which, at worst, can be hazardous to human health. As the human population and technological capabilities increase, so does the strain on nature's cleansing mechanism.

WASTE

Activity 22: Earth Resource

Are Earth's resources infinite? Demonstrate the concept of running out by putting a collection of pebbles in a container marked "Earth's resources." Have participants take turns selecting a pebble and putting it in one of three other containers, labelled "dump," "bury" and "burn." When the pebble supply is exhausted, point out that the resources have been used up. What can be done then? When should action be taken?

WATER QUALITY

Water Quality Activities

Before You Start

Consider using these topic outlines as a guide for your water quality study unit or as ideas for research projects, debates, etc.

1. Water is a valuable resource.
   - In Ontario, each person uses 300 L/d.
   - Major cities are always near water.
   - Coastline fisheries and fishing ports are important to the economy.
2. Water quality defined.
   - Water quality is important to aquatic life, wildlife and human beings.
   - Different water quality is required for different purposes (for example, drinking, bathing and irrigating).
   - We don't need pure water. We do need clean water.
   - Organisms in water need oxygen.
3. Water quality indicators.
   - Blackfly larva.
   - Sludge worm.
   - Trout.
   - Bacteria count.
   - Biological oxygen demand.
   - Dissolved oxygen and dissolved carbon dioxide.
   - Fecal coliform.
   - Turbidity, color and algae.
4. The effects of temperature on lakes.
   - The role of algae.
   - Temperature stratification.
   - Increases in temperature put stress on the system.
5. The entire watershed determines the water quality of a lake.
   - The difference between surface water and ground water.
   - Food webs and food chains.
   - Natural factors that contribute to water quality.
   - Photosynthesis in water, respiration and the role of algae.
   - Stream development.
   - Velocity and turbidity.
   - Eutrophication.
6. The water cycle.
   - Pollution can occur at any stage.
7. Sources and types of water pollution.
   - Airborne pollutants and leaching.
   - Heavy metals.
   - Coliform pollution (which leads to beach closings).
   - Visible litter and invisible pollutants.
   - Odor problems.
   - Point and non-point sources.
   - Sedimentation.
   - Toxic, heat and nuclear pollution.
   - Organic and inorganic pollution.
8. Water quality treatment methods.
   - Remove toxins, add chlorine.
   - Remove bacteria.
   - Remove solid wastes.
   - Soil conservation and land use controls.
   - Waste water treatment.
   - Septic tanks.

Activity 1: Human Effects

Look for evidence of the effect of humans on water quality. Select a shoreline for study. Consider, research and discuss these topics.

1. People use water transportation for economic gain and for leisure. What modes and methods are employed? In what ways have the modes and methods changed during the last 50 a (years)? During the last century?
2. People use water for industrial purposes, including generating power, washing, transporting, cooling and disposing of waste. Which industries are located along the shoreline? What use do they make of the available water?

WATER QUALITY

3. People live near and on water. Are there houseboats? Where are they located? Is the water used for drinking and other household purposes? Does sewage and other waste go into the water?
4. The presence of water affects the economic life of communities. Examine one community. Is water transportation used? For what purposes and to what extent? Does the presence of water attract tourists? What is the effect on the community? Is the water a help or a barrier to commercial activity?
5. People are now able to control water level and rate of stream flow. Are there dams and spillways along the shoreline? When were they built? Why? Are they still being used? Have they changed the shoreline permanently?
6. Human use of water bodies has resulted in pollution and a lowering of water quality. Is there evidence of this along the shoreline? What is it? What laws or regulations might prevent further pollution? What natural, social, economic and political factors make it difficult to enforce laws affecting water quality?

Activity 2: Definitions

Develop definitions for water pollution and contaminated water. Is either present in your area? How did it occur? Could water in your area become contaminated?

Activity 3: Water Map

Draw a water map of your community. Indicate rivers, streams, lakes and major water users. Also, mark the intake and discharge locations for the local water treatment plant.

Activity 4: Water Smell

Collect samples of water from different sources (faucet or drinking fountain, swimming pool, pond, lake, etc.). Sniff each. Do the samples smell different from each other? Why? Can the source of the sample be identified by the odor?

Activity 5: Water Residue

Put a saucer of dirty water on a window sill or a radiator. After the water has evaporated, examine the residue. Is there more or less than you expected to find? Would you be willing to drink water with these residues in it?

Activity 6: Filtration

Experiment with different methods of filtering soil particles from water. How effective is each filter? Is the filter itself changed by the water? Is the water thoroughly cleaned? Would you drink the filtered water? How expensive is this method? Is it practical to use it for producing large quantities of drinking water?

1. Try a variety of strainers on samples of water mixed with sawdust and pebbles. Let one sample stand until the pebbles sink to the bottom and the sawdust floats to the top.
2. Put a 30 cm x 30 cm piece of cloth over a window screen of the same size, and pour some dirty water through it. Repeat with different types of cloth, paper towels and paper tissues.
3. Simulate ground water action by preparing a soil filter. Cut the bottom from an empty, clean plastic bottle (such as a bleach bottle). Invert and fill with equal layers of gravel, then fine sand, then coarse sand. Invert again, and pour dirty water through the top.
4. Fill a transparent container with 750 mL of water. Add a spoonful of soil, fine sand, clay, powdered brick and miscellaneous debris. Shake well. Put the container near a window or another light source and let stand. Watch how the particles are held in suspension. Measure the settling rate. (Record the volume of material that has collected at the bottom by the end of every minute.) Note that this is

what happens during the primary settling phase of waste-water treatment. (The particles carried by water in suspension are removed by settling.)

5. Distill a mixture of water and ink or food coloring. Ink (or coloring) boils at a higher temperature than water, and so the water will boil off first. Watch the water vaporize, rise through the glass tubing, condense upon reaching the cooler glass tubing and drip out the end into the beaker.

Activity 7: Clarification

Experiment with different methods of clarifying water. What does a clarifier do? How does it work? Is it effective? Is the water thoroughly cleaned? Would you drink the clarified water? How expensive is this method? Is it practical to use it for producing large quantities of drinking water?

1. Make a clarifier from a clear plastic bottle (such as a bleach bottle). Cut off the bottom and bore a hole in the side about 5 cm from the bottom. Invert and plug the mouth with a one-holed rubber stopper which has a short piece of glass tubing in it. Connect a 30 cm piece of plastic hose to the glass tubing, and seal the free end with a tubing clamp. Place another one-holed rubber stopper, which also contains a short piece of glass tubing, in the side hole. Connect a 30 cm piece of plastic hose to the glass tubing and place the other end in a container labelled "effluent."

   Fill another container, labelled "influent," with muddy water. Slowly siphon the muddy water into the clarifier. As the clarifier fills, the water will overflow into the tube leading to the effluent container.
2. Mix equal amounts of soil in equal amounts of water in two containers of an equal size. Add about 0.5 g/L of powdered aluminum sulphate to one container. Stir both mixtures, and compare clarity at one-minute intervals.

   The alum will cause the small suspended particles in the water to stick together. They will become heavier and sink. This is comparable to the flocculation stage of sewage treatment.

Activity 8: Purification

Demonstrate why chlorine is used in water purification systems. Place a drop of stream, river or pond water on a microscopic slide and cover. Observe under a microscope. Now, place a drop of bleach on a slide containing protozoa. Observe under a microscope. The protozoa will stop moving.

Activity 9: Water Sources

Conduct a survey of drinking water sources. Does everyone in the group get water from the same source? What is it? What other sources are used in the community? Which is most commonly used?

Activity 10: Chemical Composition

What two chemical elements make up water? In what proportion? Are there any other chemicals in water? What are they? Make a display of the ingredients in water (other than oxygen and hydrogen).

Activity 11: Hygiene

What standard must drinking water meet to be considered safe by the community's health department? What factors should travellers consider before drinking water in countries other than Canada? Why are some pregnant women directed by their doctors to drink distilled water?

Activity 12: Health and Water

Research the history of health and drinking water in your community. Talk to the local department of health and to people who have lived in the community for a long time.

WATER QUALITY

Ask questions such as these:

1. When did the local department of health start checking drinking water? Why?
2. Have there been any epidemics linked to contaminated water?
3. How can scientists help prevent epidemics related to drinking water? How have they helped in the past?
4. What steps would the health department take if water contamination problems were discovered?
5. How can contamination of drinking water be prevented?

Activity 13: Water Samples

Take samples of drinking water in clean containers to the local health department or a private laboratory for testing. Are any of the samples unsuitable or unsafe for drinking? What can be done to improve the quality of these and other samples?

Activity 14: Turbidity

How may a lake in or around your community become turbid? Is it a naturally occurring or an artificial lake? Does ground water seepage run into it? Do other streams flow into it? Does a large stream help to fill it? Is it deep or shallow?

Activity 15: Algae

Set up four jars with water, soil and fertilizer mixtures as follows: 750 mL pond water; 750 mL pond water and 125 mL soil; 750 mL pond water, 125 mL soil and 4 g fertilizer; 750 mL pond water and 4 g fertilizer.

Observe, record, and discuss these questions.

1. Is algae present? In which jar is there the most algae? In which jar is there the least or none?
2. What does the algae look like?
3. Is there an odor present in the jars?
4. What is algae, and how is it formed?
5. Is algae beneficial or harmful to a stream?
6. What kind of wildlife would collect around a stream without algae?
7. How does the lack of game fish in a stream affect the wildlife around that stream?

PART TWO

ENVIRONMENTAL GAMES

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ENVIRONMENTAL APPRECIATION GAMES

These games are designed to make participants more aware of the natural environment. Since most require collecting, consider using them in conjunction with other games. Also, remind participants to be respectful of the environment.

Playing Lightly on Earth

How to Play

Divide participants into small groups. Tell each group to invent an outdoor game that does not cause serious harm to the environment, including the plants and animals living there. Encourage games which improve the immediate environment. Allow about 15 min. If time permits, give each group an opportunity to demonstrate its invention.

Variations and Notes

- Discuss a variety of games and activities that are damaging to the environment. How could they be adapted so that they became less damaging?

Scrambled Names

How to Play

Make a list of scrambled names for objects that can be found in the environment. As participants work in small groups or pairs to unscramble each name, ask them to tell where the object could be found and whether the object benefits or harms the environment.

Variations and Notes

- Have a scavenger hunt. Participants find the objects after unscrambling the names.
- Use the scrambled names to make up crossword puzzles.
- Have participants draw pictures of the objects after unscrambling the names.
- Use names for objects from around the world as a lead-in to the study of other ecosystems.
- Play backwards. Have participants collect objects first, make a list of scrambled names to suit and trade with another group or team.

My Forest Recipe

How to Play

Give each participant an index card and a pencil. Each is to write a recipe for what he/she thinks is a real forest. Discuss the results. Did everyone include all or most forest components, including living and non-living things? Discuss the components as they come up, and encourage participants to think of missing components. Emphasize the concept of ecosystem.

Scavenger Hunt

How to Play

Divide participants into small groups. Give each a list of objects to be found. Play the game as a relay race. (One member of each team goes out to hunt at any given time. The rest of the team waits until he/she returns.) The first team to collect all the objects on the list is the winner.

Variations and Notes

- Play concurrently. Each team member goes out, but each is assigned one object on the list. He/she must return with that object only.

Shape and Texture

How to Play

Give each participant a collecting bag and a list of shapes and textures (see Eco-Adjectives, page 78). Participants should scatter within a designated area and search for objects that match the shapes and textures on the list. Which was the hardest to find? Why?

Variations and Notes

- Have participants collect objects first and then supply adjectives to describe their shape and texture.

ENVIRONMENTAL APPRECIATION GAMES

Go Get It!

How to Play

Divide participants into two groups, A and B, and number off. Teams then stand opposite each other (A1 vs. B1, etc.) with the leaders standing at one end between the teams. Start by calling out something that you can see or know is nearby (for example, a leaf with smooth edges) and a number (for example, 5). A5 and B5 then run to get the object. The first to bring it back scores a point for his/her team.

Variations and Notes

- Suggestions for objects are nut, pebble, pine needle, dead leaf, rotted wood, seed, soil, cone and burr.

Memory Collection

How to Play

Divide participants into teams of two or three. Show them a display of 15 to 25 natural objects available in the local area. Give them 30 s for close study. Cover the display and send the teams out to find the objects. Allow 5 min. to 10 min. The team returning with the most objects wins.

Nature's Alphabet

How to Play

Divide participants into small groups or have them play as individuals. Give each a collecting bag and a piece of paper with the letters of the alphabet. The goal is to find one object for each letter of the alphabet. The first letter of the object's name must match the letter in order to qualify. Only one object per letter is allowed. Set a time limit (about 10 min). The winner is the one who makes the most matches.

Variations and Notes

- A variation is the last letter name game. Start the game by calling out the name of a tree. Participants take turns calling out other tree names that begin with the last letter of the tree previously called.

Nature's Discards

How to Play

Divide participants into small groups or have them play as individuals. Have them look for "nature's remains," that is, objects that are no further use to their original owner and will decay if left where they are. Examples are bark strips, burrs, feathers, nuts, fallen leaves, seed pods and twigs.

Variations and Notes

- Play as a relay game.
- Follow up with a discussion of nature's wastes. What will happen to them if left where they are? (Many will decompose and enrich the soil.) Compare them with human discards. What will happen to such items as soft drink bottles and cans, candy wrappers, etc.? Why is it important to remember not to litter the environment?

Litter Relay

How to Play

Divide participants into small groups. Tell them that each person on each team is to find a specific number of pieces of litter. On the signal, one member of each team leaves on the litter hunt. On return, he/she tags the next team member who then takes a turn. The winning team is the first to return with the total number required.

Variations and Notes

- Follow up with a note that everyone wins when everyone picks up litter.

Litter Weight

How to Play

Divide participants into teams of two. Give each a large garbage bag. The team leader stays with the bag in a central area. Other team members scramble to find and bring litter to the bag. Allow 10 min, then estimate the mass of both bags. The team which collected the heaviest total wins.

ENVIRONMENTAL APPRECIATION GAMES

Classification

How to Play

Divide participants into small groups. Each person must bring three or four non-living objects from the forest floor back to the circle. The group then arranges the objects into sets or groups according to some agreed upon criterion or rationale.

Bird Nests

How to Play

Divide participants into pairs or allow them to work as individuals. Each should pretend to be a bird and build a suitable nest using natural materials (such as long, dead grasses with some damp soil mixed in for improved support). The size can vary from 8 cm to 30 cm. Judge the nests for strength and overall quality.

Owls and Cranes

How to Play

Divide participants into two teams, the Owls and the Cranes. Line teams up facing one another and about 1.5 m apart. Draw a home base line about 3 m behind each team. Call out environmental questions. If the answer is "true," the Owls chase the Cranes. If the answer is "false," the Cranes chase the Owls. The object is to tag members of the opposite team. Anyone tagged before crossing the home base line must join the other team. The game ends when the questions run out or one team has tagged all members of the other team.

Variations and Notes

- This game may be called Crows and Cranes.
- Sample questions are:

  Sensory: "The wind is coming from behind the Cranes."

  Conceptual: "A deciduous tree keeps its leaves all year long."

  Observation: "This leaf (show one) has five points."

  Identification: "This seed (show one) came from an oak tree."

Telephone

How to Play

Sit in a circle. The leader starts by whispering an environmental message to the person on his/her right. The message is passed on until the last person receives it. He/she says it out loud. Normally, the result is a message quite different from the original.

NATURAL RELATIONSHIPS GAMES

These games are designed to make participants more aware of the relationships existing within the environment. Examples are predator/prey, food chains/food webs and adaptation/camouflage. All require active participation. Leaders are encouraged to participate, too.

Spider Tag

How to Play

Designate one participant as the spider and all the rest as flies. The spider's objective is to tag flies and form a web. The first fly tagged joins hands with the spider. Subsequently, tagged flies join hands with the last fly in the web. The spider uses his/her free hand to tag; the last fly on the web uses his/her free hand for tagging as well. Flies still free can fly through the web, but they take the risk of getting stuck and being touched by a tagging end of the web.

Variations and Notes

- Establish a boundary before the game starts. Any fly going beyond the boundary automatically becomes part of the web.
- Play again with two spiders and two webs.

Stop and Go

How to Play

The objective is for caribou to cross a field to a new food source. This involves crossing the line guarded by a wolf as quickly and quietly as possible so as not to be caught by the wolf.

Designate one participant as the wolf and all the others as caribou. The wolf stands at one end of the designated area. The caribou line up at the other end. The wolf turns away from the caribou and calls, "Go." This is the signal for the caribou to start moving towards the wolf's line.

After a short time, the wolf calls, "Stop", and turns quickly to face the caribou. Any caribou seen moving must return to the caribou starting line. The first caribou to cross the wolf's line without being seen becomes the wolf.

Variations and Notes

- Play the game with two wolves.
- Put some natural barriers (such as an imaginary stream) between the caribou and the wolf. Any caribou caught in the barrier is considered too conspicuous to be missed and therefore must return to the starting line even if not caught moving.

Quick Frozen Critters

How to Play

The objective is for rabbits to make three trips to a food source without being caught by a predator (in this case, foxes). Designate participants as predators or prey. (There should be about four to six prey for each predator.) Set up a field with one end as the permanent shelter and one as the food source. Place food tokens at the food source end. In the area between, randomly scatter five or six circles about the size of hula hoops. (String can be used as markers.) Each circle represents temporary shelter or cover.

Prey begin the game in the permanent shelter. They must reach the food source, collect a token, and return without being tagged by a predator.

Prey can avoid a predator by freezing. (This means they are not allowed to move anything but their eyelids.) Predators are not allowed to tag frozen prey. Or prey may take shelter in a circle (cover).

Tagged prey must move to the sidelines. The winner is the prey successful in making three trips to and from without being tagged.

Variations and Notes

- Allow the game to last 5 min to 10 min.

Source

Western Regional Environmental Education Council, Project Wild.

NATURAL RELATIONSHIPS GAMES

Hoppit

How to Play

The objective of the game is for hoppits to survive in their habitat, despite dangers in the form of gotchyas (prey) and disease.

Designate two participants as gotchyas and the rest as hoppits. Mark off a safety zone for the hoppits at one end of the playing area. At the other, mark off a food source zone. Put tokens representing hoppit food in it (examples are cards with food names on them or items such as cones or dead grass).

The hoppits start from their safety zone. The gotchyas roam in the area between the safety and food source zones.

Start the game with hoppits hopping (on either foot) to get one food token and bring it back to the safety zone. Hoppits may change feet, but may not use any other way of moving (such as running or skipping). The role of the gotchyas is to catch hoppits who move without hopping and call them out of the game. (This can be done by tagging or identifying by name, depending on the age of the participants.)

End the game after a suitable period of time (about 5 min) or when all hoppits have been caught by gotchyas.

Variations and Notes

- Introduce disease. Simulate by telling hoppits that they must hop only on the right foot or only on the left foot. Any hoppit caught hopping on the wrong foot or moving in any other way may be called out of the game by a gotchya.
- Introduce environmental upheaval. Simulate by telling hoppits that their safety zone has been developed for human use. Any hoppit caught using both feet while resting may be called out of the game by a gotchya.
- Introduce competition for food. Simulate by providing fewer food tokens than there are hoppits. Those hoppits who reach the food source zone too late are out of the game.

Bat and Moth

How to Play

Designate one participant as the bat and three as moths. Blindfold the bat. The rest form a circle with the bat and moths inside. The bat's objective is to find the moths using sonar. When the bat says, "Bat," the moths **must** say, "Moth." The bat then tries to tag the moths, guided by the sound. The more often the bat says, "Bat," the better chance he/she has of locating a moth. If the bat or a moth bumps into someone standing in the circle, that player must say, "Wall."

Source

Joseph Cornell, Sharing Nature With Children.

Fox and Rabbit

How to Play

Designate one participant as the fox and another as the rabbit. Divide the rest into pairs. Spread the pairs evenly around the playing area. Partners should face one another and hold hands to form rabbit holes. On the signal, the fox begins to chase the rabbit. The rabbit is safe once he/she has reached a rabbit hole. Once there, the original rabbit trades places with one of the rabbits forming the hole. The new rabbit must then leave to find a new refuge. If the fox succeeds in tagging a rabbit, that rabbit becomes the fox and the fox becomes a rabbit.

Variations and Notes

- Tell the fox to say, "Hubba, hubba," while chasing and the rabbits to say, "Eee, eee," while being chased.
- Designate more foxes to speed up the game.

Listen for Your Life

How to Play

Designate one participant as the prey and the rest as predators. Form a circle of sitting predators with the prey in the middle. Blindfold the prey and give him/her some object (preferably one that makes a noise, such as a bunch of keys). The prey sits down and puts the object in front of him/her.

The objective is for a predator to steal the object and return to the circle without being heard. The predator who succeeds becomes the next prey. The predator who fails must return to the circle and let another predator try.

The prey protects itself by listening for the predator. Upon hearing a sound, the prey has the right to point at it. If he/she points correctly (at the approaching predator), the predator has failed. If he/she points incorrectly (misses the predator), it counts as a strike against the prey. The prey is allowed three strikes. The prey must then go to the predator circle.

Variations and Notes

- The game can be made more challenging by having two or three predators on the hunt at the same time.
- This game is similar to Stalking.

Stalking

How to Play

Divide participants into pairs. One partner in each pair is designated as prey, blindfolded and lead into an open area. Prey stand with feet apart. A marker representing "life" is put between the feet of every prey. The objective of the predators is to steal a prey's "life" without being heard.

On a signal, the predators start to move towards the prey. Prey who hear predators point in the direction of the sound. Predators pointed to correctly must return to the starting line and begin again. When the last "life" is captured, predators and prey switch roles and play again.

Variations and Notes

- This game is similar to Listen for Your Life.

Phoebe and Insects

How to Play

The phoebe (pron. fee-bee) bird is a member of the flycatcher family. Designate one participant as the phoebe and the others as flies or insects. The phoebe perches on a stick (a marker on the floor) while the insects flit around taunting with buzzes and hums. The phoebe swoops from his/her perch without warning and tries to catch (tag) an insect. The insect is safe if he/she reaches a tree or other pre-determined safe spot because the phoebe can feed only in the air. Any insect caught by the phoebe in the air must then help the phoebe catch the remaining insects. The last insect to be caught becomes the phoebe for the next game.

Habitat Lap Sit

How to Play

Form a circle with participants facing the back of the person in front. Have them number off from one to four. Number ones become food, number twos become water, number threes become shelter and number fours become space.

Have participants join by placing their hands on the shoulders of the person in front and then sitting on the knees of the person behind. (This may take some practice tries.)

Call out food, water, shelter or space. Participants representing that element step out of the circle. What happens to the circle then?

Pyramid of Life

How to Play

This flexible game uses participants to build a pyramid with the players in the group. The pyramid can be made vertically or horizontally. The wide base represents plants (the producers) because all life requires plants in some way. Other levels represent consumers, starting with herbivores and ending at the top with one carnivore.

NATURAL RELATIONSHIPS GAMES

Divide participants into medium-sized groups and make sure each has a leader. It is up to the leader to assign roles to group members and place them in the pyramid.

When the pyramids are formed, call out one level. What happens to the pyramid?

Variations and Notes

- This game is similar to Habitat Lap Sit.

Food Web

How to Play

Give each participant a card with the name and picture of a component of the food chain. Have participants sit in a circle and take turns introducing themselves as the component card they hold. Then have them take turns stating which component he/she needs to survive. Use string to connect the asker with the helper. The result will be a web of strings representing the food web.

Variations and Notes

- Remove some elements one at a time, and watch what happens to the food web.

Food Chain List

How to Play

Divide participants into two or more groups. Have the leader of each team write the name of an animal on the chalkboard. The next member of the team then writes the name of something that eats this animal. The list goes on until the team can no longer come up with animal names.

Food Chain Game

How to Play

Scatter popped corn around the ground to represent plants (primary producers). Divide participants into groups representing flies (herbivores), frogs (primary consumers) and snakes (secondary consumers). A ratio of six flies to three frogs to one snake works best. Identify each group with armbands of a different colour. Release the flies to collect the popcorn in small bags. Some 30 s later, release the frogs. Their job is to eat the flies (by taking their bags of popcorn). After another 30 s, release the snakes to eat the frogs.

An individual may survive (keep the bag of popcorn) if he/she has collected a certain amount. Determine how much this must be in advance and announce it before beginning the game.

Variations and Notes

- This game works best when it is played several times. Discuss the impact as the number of herbivores and consumers is adjusted at each round.
- Add some colored popcorn to represent pesticides. This will demonstrate biomagnification as it moves through the food chain.

Overcrowding

How to Play

Divide participants into small groups. Each group represents a different animal species. Assign names, such as fish or fox.

Use string or rope to make seven to 10 circles on the ground. (Circles should be large enough to accommodate one species with a bit of space to spare.) Each circle represents shelter for a predetermined number of individuals. Before starting, announce the capacity of the circles. (It should be more than the number of individuals in the circle at the start of the game.) Assign each species to a particular circle.

Start the game. Participants wander around outside the circles. At a given signal, they must run to their designated shelter. They are not allowed to take shelter elsewhere.

On succeeding rounds, remove one circle. The homeless species must go to the sidelines. Or reduce the capacity of the circles. The participants who don't get to their circles in time must go to the sidelines.

Variations and Notes

- Introduce more participants as humans, disease or natural hazards (such as fire).

If they get to the circles before the species who belong there, they get to stay.

- Younger participants may find wearing pictures of the animals they represent helpful.

Quick Camouflage

How to Play

Select a predator and prey (such as hawks and rabbits, wolves and deer, foxes and mice, etc.). Designate one participant as the predator and the rest as prey. The predator must cover his/her eyes and count slowly to 10 (about 10 s) while the prey take cover. (Ideally, the prey should be camouflaged in some way.) The predator then opens his/her eyes and tries to spot prey. Any prey spotted must then help the predator spot other prey. The predator and prey remain in position. They use their eyes only. The game ends when all prey have been spotted or the predator gives up.

Variations and Notes

- Allow the prey only five seconds in which to hide.
- If the predator cannot find more prey after two or three minutes, have him/her close the eyes for five seconds during which the prey move closer.

Cowbird

How to Play

Designate one participant as the cowbird and the rest as other birds. The other birds each make a nest into which they deposit four objects (such as acorns or stones) to represent eggs. The cowbird does not make a nest; he/she will try to lay an egg in another bird's nest instead.

At a given signal, the cowbird tries to find an unprotected nest or get past the protecting bird without being tagged. When successful, the cowbird and other bird change places.

Source

Blair Outdoor Education Centre, Discovering Nature Through Games and Activities.

Camouflaged Worms

How to Play

Participants represent birds. Use colored toothpicks to represent worms. Scatter toothpicks within a defined area, and give the participants a limited time to find as many as they can. At the end of the time, count toothpicks. Which birds caught the most worms? Which are most likely to survive in a natural setting?

Variations and Notes

- This game works well after Bird Nests and Cowbird.

IMAGINATION GAMES

These games are designed to help participants experience the natural environment in new and exciting ways. It adds to the fun if players are encouraged to suggest and try their own variations.

Amoeba

How to Play

Participants pretend to be amoeba wandering about aimlessly. On the signal, they must form groups according to whatever instruction is given. For examples, "Amoeba 3" would mean "form groups of three."

Variations and Notes

- This game can be used as a device for forming groups to work together on a subsequent activity.
- Experiment with group sizes from small to large. Observe how the noise level increases as the group size increases.

Bird's Eye View

How to Play

Have participants lean back and look straight up through the trees to the sky (or ceiling, if played indoors). Tell them to imagine that they are birds. What would the woods look like to a bird flying overhead? What would your neighborhood look like? How big are your wings? How fast can you fly?

- Form a telescope with the hands around the eyes. Does this help the bird see more clearly?
- Try this game from the perspective of the ant threading its way through the grass and soil particles (which would seem like trees and rocks).

Stormy Weather

How to Play

This guided imagery exercise allows participants to experience a thunderstorm using only their imagination. It encourages long-term memory of an event. Begin by reading the following aloud. Follow up with a discussion of the idea that all living creatures, including humans, pets and wildlife, share a common environment and experiences within that environment.

"You are to try to imagine the things you will hear me describing. I won't put in all the details, so you must try to add what you see and feel. "Before we begin, I want you to decide who you will be during this activity. You may be either yourself or an animal. If you are an animal, you may be a wild animal, a pet or a farm animal. You will be visualizing things from the point of view of the animal you pick. Any questions?

"O.K., let's see by a show of hands how many people and how many animals we will have for this activity. How many of you are going to be farm animals? Pets? Wild animals? Yourselves?

"Now, we are ready to begin. Get yourselves in a comfortable position. Don't worry about who is sitting next to you. All of you will have your eyes closed. Just be comfortable, and do your best to imagine the things I will describe. O.K., close your eyes and imagine what you hear. . . .

"It is a late summer's night. There is a coolness in the air. You hear the sounds of summer. Somehow, you can feel some changes coming in the weather. In the distance, the dark sky is broken by bright flashes of lightning. The light is far away. After a long wait, a rolling rumble is heard. The lightning gets closer. The rumbles are louder. Suddenly, the lightning flashes and lights up the whole sky. You need to find shelter, to find a safe place. The brilliant flashes of lightning pop and crackle all around you. The noise of thunder is crashing so that the ground seems to shake. There are no longer times of quiet between the rumbles of thunder and flashes of lightning.

"It becomes still. You notice scents in the air, things you can smell and feel. You begin to hear a new sound. You are not sure what it is. If you came out thinking the storm was gone, you have to find shelter again. You need to find a place to stay dry. Suddenly, the rain is pouring down with a loud, rich sound. It rains and rains and rains. . .and then there is stillness. The storm has passed."

Variations and Notes

- When reading the paragraphs describing the storm, read slowly, keeping your voice at an even, calm pitch.
- Repeat with passages describing other dramatic natural occurrences, such as a windstorm, drought, snowstorm, flood, tornado, fire or earthquake.

Source

Western Regional Environmental Education Council, Project Wild. .

Grizzly Bear Hike

How to Play

Have participants sit in a circle and mimic everything the leader does. Start by slapping the knees (to simulate walking) and singing or chanting lines like this, pausing after each one for the group to repeat:

"Going on a grizzly bear hike,
"Going to see a big one,
"I'm not scared,
"Nice day,
"Tall trees,
"Blue sky,
"Fresh air,
"Beautiful flowers as far as the
eye can see."

Continue the hike through various obstacles, such as long grass, short grass, river, swamp, tree and hill. Upon reaching the bear's cave, describe the big eyes staring out from the cave, the realization that the eyes belong to a big bear and the quick retreat. To simulate the retreat, slap the knees more quickly and repeat all the line in reverse order.

Variations and Notes

- The leader may be the instructor. An alternative is to give participants an opportunity to take turns leading a portion of the hike.
- The leader should ham it up as much as possible.

Who Am I?

How to Play

Fasten an animal picture card to each participant's back. Have participants ask each other questions that will help them identify the animal on their back. They are not allowed to ask the question directly: "Which animal is on my back?" Instead, they must ask indirect questions, such as "Do I have four legs ?" or "Am I warm-blooded?", phrased in a way that allows a yes or no answer. They are allowed to ask each respondent only one question. Respondents are not allowed to give any information other than a yes or no answer.

Variations and Notes

- Use pictures of natural elements or non-living things.
- Allow participants to ask two or three questions per respondent.
- Set time limits for identification.

Eco-Drama

How to Play

Tell participants to imagine that they are a plant or animal. They may choose any plant or animal they wish. Ask questions. In reply, they act out their feelings, thoughts and experiences as if they were the plant or animal.

The questions should help participants imagine how plants and animals experience their world. They could begin with very practical ones (such as, "Where do you live?", "What are you eating?") and proceed to ones which promote empathy ("You sense danger ahead. What is it? How will you escape?").

IMAGINATION GAMES

Build an Animal

How to Play

Divide participants into small groups. Tell each group to create one animal by using each member of the group to represent one part of the animal's body. For example, simulate a moose with four people as legs, one as the tail and one as the head and antlers. Have groups take turns simulating the animal choice and having the other groups guess what is being represented. If you wish, allow the other groups to ask questions to help with the identification.

Making Rain

How to Play

Have participants sit in a circle and take turns mimicking the leader's action. Use a sequence which will simulate the sounds that rain make. For example, begin by rubbing two hands together and proceed to snapping fingers, clapping hands and patting knees (to represent a downpour). Then make it stop raining by making the sounds in reverse order.

Variations and Notes

- Divide participants into small groups, and have each make a rain sound pattern.
- Use stomping feet rather than patting knees for the downpour.

Discovery

How to Play

This game encourages participants to use their imaginations while heightening awareness of their surroundings.

Prepare by making several sets of of the nine letter cards (see Variations and Notes below). You should have one set for each small group.

Divide participants into small groups of four to six. Select one letter card, and give the same card to each group. (The R card is generally a good one with which to start.)

The group must read and follow the instructions on the card. Set a time limit (a minute or two). Then, give each group a chance to demonstrate how it interpreted the instructions.

If time permits, give out the rest of the cards one by one. At the end of the game, have each group sort its cards into the proper order to make the mystery word (DISCOVERY). .

Variations and Notes

- This is the copy for the nine letter cards:

D: Find something for a D, but not for a list. It has to be something you see through your fist.

I: This is a letter you'll like very much. Use your nose to find something to touch.

S: This is a letter that stands for a smell. First, you must find it, then find someone to tell.

C: This may be big, or it may be quite small. But you must see it from down in a crawl.

O: Over the head is the place for an O. So lie down on your back to get very low.

V: This is a very good letter for you. Find a high spot and look at the view.

E: E is for ear, but have no fears. An H will do too for you hear with your ears.

R: This is a letter for many a thing. But you must have everyone round in a ring.

Y: This is the toughest, but it couldn't be neater. It means that you have to be nearer than a metre.

- Playing can be spread over several sessions if time is short.
- Have each small group make instructions for each letter in the mystery word of its choice. Groups could exchange sets of letter cards, or each group could make enough sets to cover each all groups. Encourage groups to select words with an environmental connection and with a limited number of letters (for example, a maximum of five).

SENSORY AWARENESS GAMES

These games are designed to make participants more aware of all five senses and what information they can bring. Most people are accustomed to relying primarily on the sense of sight. So, many of the games in this category require participants to cover the eyes and to concentrate on using the senses of touch, taste, smell and hearing.

I Spy

How to Play

Play the traditional "I Spy" game but require participants to use objects in the natural environmental that are within view.

Variations and Notes

- Make a list of the objects as they are identified, and follow up with a discussion of the relevance of each to the environment.

Out-of-Place Trail

How to Play

Before the game starts, walk the trail to be used and deposit up to 15 objects which are out of place. Some should be natural but in the wrong place (such as a dandelion flower pinned to another plant). Some should be from the human world but hidden (for example, a green toothpick on a leaf).

Take the group on a walk and note the out-of-place objects. On return, make a list of those discovered. Repeat the walk to point out any that were missed by all or some of the group.

Mini-Magnifier Walk

How to Play

Divide participants into pairs, and give each pair a hand lens magnifier. Take them to a wooded area where trees and bushes are growing fairly closely together. One of the pair chooses a place to start and takes one giant step from that point. He/she then uses the lens to view an object and describes it to his/her partner. The partner then gets to take a giant step and describe a magnified object. The game ends when all participants have had six turns.

Micro Nature Trail

How to Play

Take participants outdoors. Have them kneel and make a window around their eyes with their hands. Tell them to look at the variety of life within their view. They should count the different plants and animals that they see. They should smell the grass, soil and ground. They should listen for special sounds and try to identify them.

Variations and Notes

- Build a mini-nature trail by giving each participant 1 m of string and having them give a guided tour of points of interest along its length. If you wish, note features and interpretations for a written "trail guide."

Counting Sounds

How to Play

This game, which may also be called Sounds of Silence, begins with participants spread out and sitting quietly with their arms and head resting on the knees. Have them close their eyes, keep perfectly still and concentrate on the sounds around them. Which sounds are the sounds of nature? Which sounds are made by humans?

After 5 min, have them take turns telling which sounds they heard and try to imitate them. Make a list.

Variations and Notes

- Have participants hold their fists up and open them, one finger at a time, as they hear and identify a sound. End the game when everyone has reached a count of 10.
- Have participants exclude bird sounds.
- Have participants use their eyes to spot and identify shades of colors.

SENSORY AWARENESS GAMES

Mating Game

How to Play

Divide participants into pairs. Each pair must choose as its call the sound a wild animal, indigenous to North America, makes (for example, "ssss" for snake). Blindfold one partner and move him/her away. The sighted partner then makes the team's sound. The blindfolded partner must find the sighted partner by using the sense of hearing.

Variations and Notes

- Add a predator by giving one participant a noisy object (such as a set of jangling keys). The predator's role is to try to tag blindfolded participants before they reach the protection offered by the sighted partner.

My Personal Tree

How to Play

Divide participants into pairs. One partner is blindfolded and one is not. The sighted partner leads the blindfolded partner to a tree. The blindfolded partner must learn as much as possible about the tree by using the other senses. The sighted partner then leads him/her back to the starting point (using confusing moves like going in circles or stepping over imaginary logs) and takes off the blindfold. He/she must then relocate the tree. Repeat with the partners reversing roles.

Variations and Notes

- This game works particularly well in an area where there are many of the same species of tree.

Blind Walk

How to Play

Have participants take off one shoe and sock and then find a place along a rope long enough for everyone. All should then be blindfolded or close their eyes. The leader (who takes off a shoe and sock but is not blindfolded) then takes the group on a walk which has a variety of walking surfaces (such as concrete, grass, sunny, shaded, gravel and puddles).

Variations and Notes

- Take care to avoid dangers, such as broken glass or sudden changes in elevation which could cause someone to trip.

Environmental Touch

How to Play

Collect and cover a display of a variety of objects, including objects from the natural environment. Divide participants into pairs and blindfold one partner. Have the sighted partner choose an object from the display for the blindfolded partner to describe and identify. Switch roles.

Variations and Notes

- Instead of giving the object to the blindfolded partner, touch him/her with it in various places (like on the palm, on the top of the hand, on the cheek, on the arm). Can he/she guess what it is?
- Have the sighted partner hide the object after the blindfolded partner has become familiar with its texture and shape. The blindfolded partner then takes off the blindfold and draws a picture of the object. When finished, the picture and the object should be compared.
- Have the blindfolded partner draw a picture of the object while still blindfolded.

Grab Bag

How to Play

Collect about 15 different natural objects (such as a pine cone, acorn, piece of dead bark, pebble, shell, feather, milkweed pod and burr) and put them in a bag. Blindfold participants and pass the bag around. Give each person the same amount of time to feel the objects in the bag. Then have them list as many as they can identify and remember. Give participants an opportunity to read lists aloud.

SENSORY AWARENESS GAMES

Different Odors

How to Play

Divide participants into small groups and assign an adjective describing a smell to each. (See Eco-Adjectives, page 85, for suggestions.) The group's task is to develop a list of objects which have that smell.

Variations and Notes

- Turn the game into a scavenger hunt. Have participants find objects that have that smell.

Hunter's Hike

How to Play

Have participants form a single file line and walk through a wooded area as silently as possible. Tell them to pretend to be hunters who are trying not to make any noise while listening for sounds of birds or game animals in the area.

Duplication

How to Play

Collect 10 natural objects and place them on a white backdrop. Cover them with an opaque cloth. Give participants 25 s to look at what is under the cloth. Replace the cover, and send participants out to find as many of the objects as they can remember. Set a time limit. When they return, hold up each object in turn and take a count of how many participants were able to match it. If possible, tell an interesting story about each object as it is held up.

HUMANS AND THE ENVIRONMENT GAMES

These games are designed to help participants develop ways of dealings with environmental problems. The focus is on role playing.

Enough Is Enough

How to Play

This simulation focuses on a local problem involving excessive noise and litter from a popular restaurant. The owner of the business claims that controlling and cleaning up would result in bankruptcy and the consequent loss of jobs. Residents in the community as a whole like the restaurant, enjoy visiting it and would not like to see it closed down. Residents living near by feel the same way but also feel that something must be done about the noise and litter. The town's council has decided to have a special meeting to discuss the issue and try to find a workable solution.

The meeting will be chaired by the mayor and be attended by council members. Presentations will be made by the restaurant owner, three teenage employees, an elderly couple who live near by, the owner of another local business, the school's principal, a teacher from the school, a lawyer and six other individuals who live in the town (three who patronize the restaurant and three who do not).

Assign participants to various roles, or allow them to select roles. Each should do research and develop a brief presentation. The presentations may include visuals, such as maps of the community, photographs of the alleged litter, etc. (Note that the mayor and council members will ask questions rather than make presentations.)

The rest of the participants will play the role of interested citizens who attend the meeting and vote (by a show of hands) on various proposed solutions.

Variations and Notes

- Use this roleplay model to discuss other environmental issues, including problems presently in the news in your local area.
- If the issue is drawn from a current local issue, remind participants that they are to create fictitious characters with fictitious names.

The Great Debate

How to Play

This simulation focuses on the issues that arise around urban development. The owner of a piece of land on the outskirts of town wants to build a new housing development. The architect, who has an impressive track record with this type of project, has promised that the design will blend into the natural surroundings and not cause any environmental damage. Members of a local environmental interest group are not convinced, however. They say that the site is one of the last in the area that provides a natural habitat for wild flowers and small animals and one of the last where residents can observe nature close up. The town's council has decided to have a special meeting to discuss the issue and try to find a workable solution.

The meeting will be chaired by the mayor and be attended by council members. Presentations will be made by the owner of the land, the architect, a construction worker, the leader of the environmental group, a backpacker, a horseback rider, two people who wish to buy homes in the new development, a birdwatcher, three local residents, a tree, a deer, a salamander and a trillium.

Assign participants to various roles, or allow them to select roles. Each should do research and develop a brief presentation. The presentations may include visuals, such as maps and photographs of the site, plans showing the proposed design, etc. (Note that the mayor and council members will ask questions rather than make presentations.)

The rest of the participants will play the role of interested citizens who attend the meeting and vote (by a show of hands) on various proposed solutions.

Variations and Notes

- Use this roleplay model to discuss other environmental issues, such as a hotel in a residential area, an office tower twice the height of surrounding buildings, a recreational complex, a power plant, a factory, etc.
- If the issue is drawn from a current local issue, remind participants that they are to create fictitious characters with fictitious names.

PART THREE

APPENDICES

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APPENDIX A

Eco-Adjectives

These adjectives are provided as a starter list to use as appropriate with the games and activities. It may also be used as the basis for a language development activity which challenges participants to develop their own resource banks of words and phrases to describe the natural environment. Note as well that many terms may apply in more than one category.

Colors	Shapes	Smells	Textures
Blue	Round	Mild	Hard
Green	Square	Sharp	Soft
Orange	Oval	Floral	Wet
Purple	Rectangular	Fruity	Dry
Yellow	Triangular	Moist	Smooth
Red	Cylindrical	Musky	Rough
Light	Conical	Oily	Coarse
Dark	Branching	Pine-like	Fine
Bright	Irregular	Spicy	Sharp
Dull	Enlarged	Sweet	Dull
Loud	Shrunken	Woody	Solid
Quiet	Expanded	Warm	Hollow
Fluorescent	Collapsed	Burnt	Warm
Metallic	Fat	Fishy	Cool
Shiny	Skinny	Foul	Furry

APPENDIX A

Eco-Adjectives Cont'd.

Colors	Shapes	Smells	Textures
	Thick	Pungent	Fuzzy
	Thin	Rich	Velvety
	Curved	Urine-like	Hairy
	Ridged	Inky	Shaggy
	Flat	Slick	
	Wavy	Slimy	
	Flaky	Sticky	
	Oblong	Oily	
	Pointed	Waxy	
	Jagged	Ribbed	
	Knobbed		
	Lumpy		
	Prickly		
	Porous		
	Spongy		
	Rubbery		
	Squishy		
	Rustling		

APPENDIX B

Common Water Pollutants

Type	Sources	Effects
Oxygen-demanding wastes	Domestic sewage Industrial sewage (from tanning factories, paper mills and food processing plants)	Overload the waste-neutralizing process of water Deplete oxygen supply of water body (ultimately kills fish)
Disease-causing organisms	Dairies Infectious organisms in sewage Industrial waste (in tanning, meat packing and other plants)	Carry diseases such as typhoid, dysentery, cholera and hepatitis Note that disinfection techniques have greatly reduced disease from these sources

APPENDIX B

Common Water Pollutants Cont'd

Type	Sources	Effects
Plant nutrients	Nitrogen and phosphorus drained from fertilized land Sewage Phosphorus from detergents	Stimulate excessive growth of aquatic life (such as algae and water plants), which uses up available oxygen, thus choking out other forms of life Interfere with the treatment process Cause unpleasant odors and tastes in water Cause unsightly conditions in water

APPENDIX B

Common Water Pollutants Cont'd

Type	Sources	Effects
Synthetic organic chemicals	Detergents and other cleansing agents Synthetic organic pesticides Synthetic chemicals used in industrial processes Industrial waste from breweries, paper mills, slaughterhouses, canneries, textile mills and dairies Manure, ensilage and other agricultural residues	Cause offensive odors Are toxic to fish and other aquatic life Cause unpleasant taste in water Harm human health Resist conventional waste water treatment

APPENDIX B

Common Water Pollutants Cont'd

Type	Sources	Effects
Excessive sediment	Particles in soil, sand and minerals washed from land and paved areas Debris from construction sites	Fill stream channels, harbours and reservoirs Reduce the amount of sunlight penetrating the water, thus affecting the photosynthesis process of green aquatic plants Cause unsightly conditions Erode power turbines and pumping equipment, thus increasing water treatment costs Reduce fish populations by covering fish nests and food supplies Reduce the water's capacity to absorb oxygen and assimilate oxygen-demanding wastes
Heat	Cooling of industrial machinery, power generators, and nuclear reactors	Raise water temperature beyond acceptable temperature ranges, thus killing some plant and animal life
Radioactive substances	Mining and processing radioactive ore Use of refined radioactive materials in power reactors and in industrial, medical and research operations	May cause human public health problems

APPENDIX B

Common Water Pollutants Cont'd

Type	Sources	Effects
Inorganic chemicals and minerals	Acids, metals, salts and solid matter Other chemicals from oil refineries and chemical factories Manufacturing and agricultural activities Hydrocarbon fallout from coal and oil heating Oil from tanker spills and equipment leaks Radioactive substances	Interfere with natural stream purification Destroy fish and other aquatic life Cause excessive water hardness Corrode water treatment equipment May cause cancer Cause gene mutations and birth birth defects (radioactive substances only)

APPENDIX C

Glossary

Use these definitions as a quick reference guide to common meanings in an environmental science context. Note that other meanings may be found in standard reference works.

A

Adaptation: The process of modifying a plant's or animal's structure according to conditions in its environment in order to allow the organism to survive. For example, many insects elude predators by adopting the color of the plants on which they live.

B

Biomagnification: The gradual increase in concentration of toxins in the flesh of creatures higher in the food chain.

Biodegradable: A substance that can be broken down into its constituent parts or a simpler form by the action of micro-organisms.

C

Carnivore Meat-eating.

Carrying capacity: The maximum number of living organisms whose life can be supported within a given area. This number can vary from season to season as circumstances and conditions (such as the size of the food supply) vary. If the capacity is exceeded, some of the organisms will die or be forced to leave the area and the area itself may be adversely affected.

Community: A group of living organisms sharing a physical environment. This may be a group of plants living on a rock boulder or a group of human beings sharing a town.

Conservation: The wise use of natural resources so that some portion is available to future generations.

Consumer: One who uses or eats. In environmental science terms, plants are defined as producers, and a primary consumer is defined as a creature that eats plants. A secondary consumer is defined as a creature that eats primary consumers.

D

Decomposer: A micro-organism that breaks down dead organic matter into its constituent parts or a simpler form.

Domesticated: Animals that depend on humans for food, shelter and life. .pa

E

Ecology: The science of living organisms and their relationships with the living and non-living environment.

Ecosystem: A number of communities which share a given area and interact with each other and the non-living environment.

Empathy: Understanding the thoughts, feelings and experiences of others.

Environment: The surroundings, including air, land and water.

F

Food chain: The movement of energy from one living organism to another through the process of eating and being eaten.

Food web: A series of interrelated food chains.

H

Habitat: The food, water and shelter required by a plant or animal in order to survive in a given area.

APPENDIX C

Herbivore: Plant-eating.

N

Niche: A habitat that supplies all the factors needed to support the existence of an organism or species. Also, the ecological role of an organism in a community, especially with regard to food consumption.

O

Omnivore: Plant- and meat-eating.

P

Pool: A slow-moving or stationary body of water.

Predator: An organism that hunts other organisms for food.

Preservation: To maintain a given area in its original state.

Prey: An organism that is hunted for food by a predator.

Producer: An organism that makes its food from sunlight.

Q

Quadrat: An area of land amounting to one square metre marked off for the study of plants and animals.

R

Read the woods: Speculating about the history of a wooded area by observing its current state. For example, short trees with low, horizontal branches indicate that the area was likely an old field in the recent past. **Resource:** Components of the environment of use or potential value to a living organism within it. Usually used to describe components useful to humans.

Riffle: A fast-moving body of water.

S

Shelter: Any form of cover that shields a plant or animal from the elements. One component of the habitat.

Species: A group of individuals that can breed with one another and create fertile offspring.

Succession: The gradual change in the plant and animal life within a given area. An example is a field which becomes a forest through the gradual process of grasses being replaced by shrubs and trees.

T

Terrestrial: Earth- or ground-dwelling.

Turbidity: The clarity of water. How far one can see into it. Turbidity can be measured with a Secchi disk (a 20 cm, white disk). The depth at which the disk disappears from sight gives a turbidity reading. A 2.5 cm reading means the water is very turbid, or muddy. A 40 cm reading is much less turbid but likely still brownish or muddy in appearance.

W

Wildlife: Animals that do not depend on humans for food, shelter and life.

APPENDIX D

Resources

Bosak, Susan, and Anthony Gower. Science Is. Ottawa: Youth Science Foundation, 1986. (This Canadian book provides a variety of science activities and ideas suitable for all ages. Categories include the science Olympics, matter and energy, humans, environmental awareness, rocks, plants, living creatures, weather, the heavens and applying science.)

Cornell, Joseph. Sharing Nature With Children. Vancouver: Gordon Soules, n.d.

Flanagan, Frank, et al. Focus on Science. Toronto: D.C. Heath Canada Limited, 1982. (This Canadian core science program covers Grades 4 to 6.)

Girling, Williams (Ed.). Making Nature a Natural Experience. Toronto: Government of Ontario, Ministry of Tourism and Recreation, Recreation Branch, 1982.

Project Wild. Boulder: Western Regional Environmental Education Council, 1983. (This interdisciplinary, supplementary, environmental and conservation education program is designed for teachers to use with students from kingergarten to high school. Available free but only to educators who attend in-service workshops. For more information, contact Wildlife Branch, Ontario Ministry of Natural Resources, 99 Wellesley Street West, Toronto, Ontario M7A 1W3.)

Reeves-Steven, Judith, and Garfield Reeves-Stevens. Science Around Me. Toronto: Gage Educational Publishing, 1987. (This 45-title, activity-based Canadian program for Grades 1 to 3 deals with such topics as weather forecasting and seasonal change; causes and effects of acid rain; life cycles of plants; reversible and irreversible change; and population, habitat and environment. Children are introduced to scientific concepts at work in familiar technological applications.)

SEEDS (Society, Environment, and Energy Development Studies): The Energy Literacy Series. Edmonton: The SEEDS Foundation, 1983. (This Canadian program provides a complete K to 12 energy curriculum or a supplementary series of energy units for use in a core science or social studies curriculum. Available free but only to educators who attend in-service workshops.)

NOTES

NOTES